# QA Manual for Asphalt Materials
# Pilot Special Provision

## APPLICATION OF QUALITY ASSURANCE SPECIFICATIONS FOR ASPHALT CONCRETE MIXTURES

**Jointly Developed by**
**Technology Transfer and Training**
**and**
**the Materials and Construction Sections**
**of the**
**Louisiana Department of Transportation and Development**

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# CREDITS

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# PART 1 – POLICY

## Policy

This document describes the implementation of Part V, 2015 Standard Specifications for Roads and Bridges which incorporates several new policies; Contractor data used in the acceptance decision, planned verification, dispute resolution and System Independent Assurance,

The purpose of this manual is to supplement Part V of the 2015 LA Standard Specifications for Roads and Bridges, standardize policies and procedures, provide detail, explanation and examples, denote personnel requirements, and denote equipment and process requirements, all with the goal of facilitating uniform application of the specifications during the design, production and placement of Asphalt concrete and associated work.

**Specifications** - This manual is to be used in conjunction with the 2015 Edition of the *Louisiana Standard Specifications for Roads and Bridges, or "Spec Book".* Relevant specifications are referenced throughout this manual. Specifications may be repeated in order to further detail or demonstrate how they are applied. **All specifications, manuals, forms and spreadsheets are subject to change. Therefore, it is imperative that contract documents for each project be reviewed for any specific change, Special Provision, Supplemental Specification, update and/or addition.**

**Manuals** – Numerous manuals which are essential for performing DOTD Asphalt related work are listed below. The latest edition of each shall be available at the hot mix asphalt (HMA) production plant and at the district laboratory. Any required document can be obtained from the department at a published price through General Files at 225-379-1107. Many manuals are listed at http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Materials_Lab/Pages/default.aspx **,** hereafter referred to as "website". Following each manual description are instructions for locating the documents on the website.

Documents are:

- CONTRACT DOCUMENTS – the legally binding written agreement between the DOTD and the Contractor setting forth obligations for the performance of work for a specific project. *(not on website)* This may include Special Provisions or Supplemental Specifications.

- 2015 EDITION of the LOUISIANA STANDARD SPECIFICATIONS for ROADS and BRIDGES – (known as "Standard Specifications") the terms and stipulations for providing materials, services and the finished constructed product. http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Standard_Specifications/Pages/default.aspx

- MATERIALS SAMPLING MANUAL – (known as "MSM") SAMPLING PLAN – The MSM establishes and standardizes sampling and acceptance requirements for Louisiana Department of Transportation and Development. The MSM determines what contract items are to be sampled and tested. Documentation, frequency, quantity and procedures for meeting project sampling requirements are detailed in the MSM. It can be found on the Materials Lab website: http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Materials_Lab/Pages/default.aspx

- TEST PROCEDURES MANUAL – all standardized DOTD test procedures, which are denoted, "DOTD TR-xxx". http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Materials_Lab/Pages/default.aspx

- ENGINEERING DIRECTIVES AND STANDARDS MANUAL – (known as "EDSM") establishes policies and procedures for DOTD Design, Construction, and Maintenance. An example is "haul truck certification". http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/EDSM/Pages/default.aspx

- Approved Material List (Formerly known as "QPL") – a listing of materials which have been evaluated by DOTD. It lists companies that have demonstrated the ability to supply a product of acceptable quality. Project acceptance or verification testing is required of many products appearing on the Approved Materials list. http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Materials_Lab/Pages/Menu_QPL.aspx
  Qualification Procedures for each category of Approved Materials is also listed here.

- DOTD CONSTRUCTION MEMORANDA – The DOTD's internal office documentation to explain various construction issues. (Only available to DOTD Employees on the Intranet. Go to ***Construction Home Page***, to ***Construction Memos.)***

- CONSTRUCTION CONTRACT ADMINISTRATION MANUAL – Instructions for DOTD Project Engineers and their representatives which include procedures for change orders, estimates, diaries and field book entries. http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Misc%20Documents/Construction%20Contract%20Administration%20Manual.pdf

- AASHTO TEST PROCEDURES – a set of nationally recognized test procedures and specifications published by the American Association of State Highway and Transportation Officials.
  **http://www.transportation.org/** go to ***bookstore.***
  At the time of this writing, DOTD personnel have access through the LTRC "Library/Information Services".

- ASTM TEST PROCEDURES – a set of nationally recognized test procedures published by the American Society for Testing and Materials.
  ***www.astm.org***, to ***Standards***, then search. DOTD personnel may contact the District Lab Engineer. At the time of this writing, DOTD personnel have access through the LTRC "Library/Information Services".

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- ADMINISTRATIVE MANUAL for CONSTRUCTION TECHNICIAN TRAINING AND CERTIFICATION – certification and training requirements for performing construction inspection.
  http://www.ltrc.lsu.edu/certification.html

- APPLICATION OF QUALITY ASSURANCE SPECIFICATIONS FOR ASPHALT CONCRETE MIXTURES – used in conjunction with and supplement Part V of the Louisiana Standard Specifications for Roads and Bridges for the design, production, and placement of Asphalt Concrete and associated work.

# PART 1 – POLICY

## A. Documentation

**Forms and Spreadsheets** – Data input by the contractor and DOTD personnel will be required. The District Laboratory Engineer (DLE) will provide information on the current program and software requirements. Examples of templates and spreadsheets shown in this manual are current as of the manual's publication date.

**Rounding for Test Procedures** – Site Manager Materials will utilize computer rounding for all test results and sample locations.

**Rounding for Pay** – Rounding for estimates and pay determination are to be in accordance with the Construction Contract Administration Manual or current Site Manager® construction policies. Asphalt mixture is paid to the whole percent. If the tenths position is less than 5, round downward; if greater than or equal to 5, round upward. For example 99.3 rounds to 99% and 99.5% rounds to 100% pay. Intermediate calculations are rounded to two more decimal places than the final answer.

## B. Definitions

**Acceptance program**
All factors that comprise the determination of the quality of the product as specified in the contract requirements. These factors include verification sampling, testing, and inspection and may include results of quality control sampling and testing.

**Aggregates**
Coarse aggregate will be defined as material retained on the No. 4 sieve.
Fine aggregate will be defined as material passing the No. 4 sieve.
Coarse aggregate stockpiles are defined as when >50.0% of the material is retained on the No. 4 sieve.
Fine aggregate stockpiles are defined as when >50.0% of the material passes the No. 4 sieve.

**Asphalt District Inspector (ADI)**
DOTD Asphalt Plant Certified Inspector and is the representative of the District Laboratory Engineer.

**District Laboratory Engineer (DLE)**
The coordinating authority of the district's quality assurance program and the representative of the department in the area of materials quality. This coordination is in conjunction with the DOTD Materials Engineer Administrator.

**Independent Assurance Program (IA)**
The IA Program is covered by regulation 23 CFR 637. The technical brief can be viewed at: http://www.fhwa.dot.gov/pavement/materials/hif12001.pdf .
Independent Assurance can be defined as: Activities that are an unbiased and independent evaluation of all the sampling and testing procedures used in the acceptance program.

**LaPave**
The current DOTD approved spreadsheet for asphalt mixture design submittal and reporting of asphalt mixture testing.

**Proficiency samples**
Homogeneous samples that are distributed and tested by two or more laboratories. The test results are compared to assure that the laboratories are obtaining the same results.

**Qualified laboratories**
Laboratories that are capable as defined by appropriate programs established by DOTD. As a minimum, the qualification program shall include provisions for checking test equipment and the laboratory shall keep records of calibration checks. Qualified laboratories shall be accredited by AMRL, CMEC or other DOTD approved accreditation body.

**Qualified sampling and testing personnel**
Personnel who are capable as defined by appropriate programs established by DOTD.

**Quality assurance (QA)**
All those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality.

**Quality control (QC)**
A procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer.

**Random sample**
A sample drawn from a lot in which each increment in the lot has an equal probability of being chosen.

**Verification sampling and testing**
Sampling and testing performed to validate the quality of the product.

## C. Safety

Both DOTD and contractor personnel are to exercise caution while performing their duties at the plant/laboratory and in the field. They are to follow all safety procedures during sampling, testing and routine plant/roadway inspection in accordance with the Testing Procedures Safety Guidelines.

## D. Environment Protection

Activities that negatively impact the environment potentially exist on every construction project, whether at construction sites, material producing plants, or equipment staging areas. Potential hazards can come from:
Storm water runoff, because it carries residues from asphalts, oils, fuels, fertilizers, and chemicals that can be hazardous to the environment.
Air, because vapors from materials such as fuel and oils can be carried away from the site.
Noise, because vibrations that can cause soil subsidence resulting in structural damage to buildings and water table changes and high noise levels can impact hearing of individuals.

There are local, state, and federal guidelines that control these activities to minimize environmental harm. The contractor shall abide by these regulations and is to take every step necessary to prevent damage to the environment. Section 107.14 of the Standard Specifications covers Environmental Protection procedures.

Erosion control is critical on a project. Pursuant to the Clean Water Act and the Louisiana Environmental Quality Act, a Louisiana Pollution Discharge Elimination system (LPDES) General Permit is required from the Louisiana Department of Environmental Quality for any construction activity. Two different permits are required: one for any project that disturbs from one to five acres, and a separate one for any project that disturbs five or more acres. A Storm Water Pollution Prevention Plan (SWPPP) is required for these projects and normally consists of:

- Plan sheets indicating the location of erosion control items
- Standard Plan EC-01
- Standard Specifications Section 204

If there is no erosion control plan in the project plans, the project engineer is to contact the Headquarters Construction Section to find out if one should be added. The SWPPP shall be discussed at the pre-construction meeting.

## E. Contractor Notification

The contractor shall notify the District Laboratory Engineer and/or their representative by the close of the preceding business day of anticipated plant production. For ongoing projects, notification shall be sent the same day before the termination of production and shipping. This ensures the DLE the opportunity for inspection during production and shipping.

## F. Consequences of False Reporting or Misinformation

In the event an employee of DOTD or the Contractor questions the professional conduct of either the department or contractor, they shall bring evidence immediately to the District Lab Engineer. If the contractor or their representatives is found to be falsifying information or intentionally misinforming the Department, then the contractor's plant and/or its representatives will not be allowed to supply or work on DOTD's projects for a period of one year. The determination of suspension will be conducted by a committee formed of members of the Department (District Lab Engineer and Materials Engineer), AGC, and FHWA. If a DOTD employee or DOTD representative is proven to provide misinformation or falsifying information they will be subject to discipline action outlined in DOTD PPMs.

# PART 1 – POLICY

## Chapter I. Quality Assurance

This chapter defines and describes the elements of Quality Assurance.

Quality Assurance is the combined efforts of quality control and acceptance processes to assure that a project will provide the public with a durable product exhibiting a high level of performance. A quality assurance system provides a level of confidence that our finished product will be of good value. This system includes:

1. Preliminary Source Approval of Materials
2. Certification or Qualification of Technicians
3. Certification of Equipment and Processes
4. Quality Control
5. Inspection, Sampling and Testing
6. Verification Sampling and Testing
7. Documentation
8. Acceptance
9. Independent Assurance Program

a) *Preliminary Source Approval of Materials*

The Materials Sampling Manual kept online on the Materials Section Website, outlines the inspection, sampling and testing requirements of all materials. Source materials which require long term testing and regular source verification testing are required to comply with qualification procedures and testing requirements. The acknowledgement of compliance with department requirements is signified by appearance on the Approved Materials List (AML), also available online on the Materials Website.

b) *Certification or Qualification of Technicians*

Certified and/or qualified technicians are required to ensure that the personnel are adequately trained and capable to perform design, sampling, testing, and inspections. The Contractor's technicians shall be certified to sample, test, design, produce, control, and make adjustments to their operation. Requiring the use of certified technicians, equipment and processes further ensures the likelihood of acceptable quality. When producing Asphalt Concrete, the contractor shall employ a Certified Asphalt Concrete Plant Technician in accordance with specification requirements. This qualified technician must be present at the plant or the job site whenever plant operations are supplying materials to a DOTD project. Daily plant operations shall not commence unless the Certified Technician is present. Technicians for both the contractor and DOTD shall be qualified and/or certified for testing according to the levels listed below.

The qualification/certification levels for an Asphalt Plant Technician are as follows:

**Qualified Aggregate Tester**

**Qualified Asphalt Concrete Plant Level I**

**Certified Asphalt Concrete Plant Level II**

**Certified Asphalt Concrete Plant Level III**

See Appendix for detailed training requirements

All requirements for certification are outlined in the Department's Administrative Manual for Inspector/Technician Training and Certification. This manual is available at http://www.ltrc.lsu.edu/certification.html.

All technicians involved in QA/QC sampling and testing of asphalt mixtures for DOTD are required to complete the appropriate level of training in accordance with The Training Program for HMA Plant Technicians.

The DOTD Materials Engineer Administrator is the certifying authority for the Department for certification of Asphalt concrete plant and paving inspectors and technicians. When a certified or authorized inspector or technician is performing substandard work, is not able to satisfactorily perform the duties routinely required of certified or authorized personnel, engages in unethical activities, the certification or authorization may be revoked. Proceedings to revoke a certification or authorization can be initiated by DOTD representatives or industry, including, but not limited to: department certified inspectors, district training specialists, laboratory engineers, area engineers, project engineers, construction engineers, or any member of the Certification Committee. The appropriate representative of the employing firm may also request revocation of certification or authorizations granted to non-department personnel.

Personnel must participate in the proficiency sample program and keep certifications current. Failure to update by the established expiration date will result in the expiration of the certification. The certification will remain expired until the required steps are taken to reestablish certification credentials.

The Department's paving inspector must be certified in the area of Asphalt Concrete Paving Inspection. Certification in this area also requires successful completion of an examination and following a minimum of six months experience, a performance examination in roadway paving.

All Department and non-department technicians and inspectors are expected to continually monitor the production process for conformity to specifications and consistency. It is expected that certified personnel conduct their duties of quality control and quality assurance in a cooperative, professional, and ethical manner.

Further, it is a requirement of asphalt concrete technicians to complete all testing, documentation, and submittals in a neat, orderly, and timely fashion. Details of the required documentation are provided throughout this manual.

c) *Certification of Equipment and Processes*

The certified plant will have a sticker issued showing the date certified. Asphalt plant lab testing equipment must be calibrated and verified in accordance with Section 503 of the Standard Specifications and Chapter VI of this manual. All scales, meters, and measuring devices shall be officially calibrated by a private, licensed testing company, or the Weights and Standards Division of the Department of Agriculture and Forestry.

Asphalt plant labs must be accredited by AMRL, CMEC, or another accreditation body approved by DOTD. It is mandatory that all required test reported for design submittals and reported for daily production be performed by an accredited laboratory by a certified technician. Certified equipment and processes ensure that the plant and paving equipment are in good working condition and capable of producing the required level of quality. The contractor shall provide plant, field and testing equipment that is in good condition and appropriate for the tasks for which it is used. A list of required plant laboratory equipment is included in Chapter VI.

Prior to construction, a DOTD representative will inspect the roadway equipment to be used on the project to ensure that it is in good working condition and appropriate for the activity for which it is to be used. The inspector will require that equipment which leaks or is damaged be repaired or replaced before it will be allowed to operate on the project.

d) *Quality Control*

Quality Control is the process used by the contractor to monitor, assess, and adjust material selection, production, and project construction to control the level of quality so that the product continuously and uniformly conforms to specifications.

Minimum requirements for quality control sampling and testing are denoted in the specifications and the Materials Sampling Manual. When necessary, the contractor shall sample and test as needed to ensure quality. The quality control requirements listed in the specifications shall be entered into the Department's approved software program.

When approaching borderline conditions, a contractor may make adjustments to operations or materials. When borderline materials or operations result in failing plant gradation and volumetric test, or roadway density tests, immediate adjustments will be required to correct the deficiency and prevent its reoccurrence.

e) *Inspection, Sampling and Testing*

Inspection is the observation of materials, samples, tests, equipment, processes and the finished product to determine the quality of the product, to determine the quantity or the amount to pay for the product. Technicians document test results and where the product is placed. Inspection may reveal areas of concern resulting in additional discussion, investigation, or further testing. The project engineer is the direct representative of Chief Engineer for the administration of the contract and represents the department directly, as well as through the inspection staff.

Sampling and testing is a support for visual inspection. Although the random, statistically based sampling and testing performed by the Department represents the entire area or lot being tested, this methodology does not replace visual inspection. Department personnel will observe the contractor's operations and inspect the project throughout its construction. When non-uniform materials or non-uniform processes result in areas which do not appear to be acceptable or which are obviously not in conformance with the quality of construction expected, the Department will require the contractor to correct these deficient areas. It has never been the intent of the department to accept a project solely on the basis of the sampling and testing program. It is always necessary for the project engineer and inspector to be aware of the quality of construction and performance of the project during construction and acceptance phases before final acceptance.

Sampling and testing requirements for materials or processes specified in Supplemental Specifications or Special Provisions are not usually included in the Materials Sampling Manual. If no sampling or testing requirements are published, the Project Engineer will determine sampling and testing.

f) *Verification Testing*

Validation is a specific type of verification testing, performed jointly by the contractor and DOTD, which is used to determine the viability of a laboratory-designed asphalt Job Mix Formula based upon test results of plant-produced mixtures. Validation is usually performed on the first day of asphalt plant production and determines if the plant-produced mixture conforms to the proposed job mix formula.

g) *Documentation*

Documentation provides a history of each project and a track record for contractors and/or technicians. Documentation shall be maintained within the DOTD approved software program. Contractors shall provide signed plant reports for each mix on each project to the DLE for inclusion in the project summary. This may be either a paper copy with signature or an electronic copy with a DOTD approved electronic signature. The report will be generated in a DOTD approved software that includes summaries of all required DOTD testing and reportable parameters. Contractor provided summary reports shall be required to close out all DOTD projects with Asphalt Concrete unless otherwise stated.

The Contractor shall maintain records of all testing for state projects at the production plant. Such documentation will be available to DOTD.

The Contractor shall document quality control and acceptance testing. In addition the Department shall summarize the project-specific sampling and testing at the end of the project in the 2059, or Summary of Test Results, in accordance with EDSM III.5.1.2.

The contractor shall make all accreditation documents available for review upon the Department's request.

h) *Acceptance*

Acceptance is the product of sampling, testing, and inspection which defines the degree of contract compliance. Acceptance is based on the degree of compliance with specifications for acceptance of materials and/or contractor's work. Acceptance sampling, testing and inspection is the responsibility of the DOTD. Use of contractor sampling and testing in the acceptance decision is allowed by specifications. At the end of a construction phase, through evaluation of all sampling, testing, and visual inspection, the department will determine pay and provide final acceptance notice to the contractor.

i) *Independent Assurance Program*

The IA Program provides confidence that uniform testing and equipment exists in all facets of the Quality Assurance Program. See Chapter II for more detail of the System Independent Assurance Program

<u>Laboratory Accreditation and Certification</u>

1) **The contractor asphalt plant lab will be accredited by AMRL, CMEC or other accreditation body approved by DOTD in accordance with AASHTO R18.**

2) **DOTD Materials Engineer is the certifying authority for all laboratories (Contractor and District Labs). AMRL or CMEC accreditation does not guarantee DOTD certification.**

3) **DOTD reserves the right to decertify laboratories when contractors fail to rectify noted non-conformance to the policies.**

# PART 1 – POLICY

Requirements of DOTD District Labs, Asphalt Production & Design Laboratories for Accreditation through AMRL, CMEC or other DOTD approved accreditation body.

**Test Methods for Accreditation**

| Description | DOTD Test Method | AASHTO/ASTM |
|---|---|---|
| Specific Gravity & Density of Compressed Asphalt Concrete Mixtures [1, 2, 3] | DOTD TR 304 | T 166/D 2041 |
| Theoretical Maximum Specific Gravity, $G_{mm}$ [1, 2, 3] | DOTD TR 327 | T 209/D 2041 |
| Asphalt Cement Content, $P_b$ [1, 2, 3] | DOTD TR 323 | T 308/D 6307 |
| Mechanical Analysis of Extracted Aggregate[1, 2, 3] | DOTD TR 309 | T30/D 5444 |
| Moisture Content of Loose HMA [1] | DOTD TR 319 | T329 |
| Degree of Particle Coating (Ross Count) [1, 2, 3] | DOTD TR 328 | |
| Coarse Aggregate Angularity (% Double Faced Crushed) [2, 3] | DOTD TR 306 | T 335/D 5821 |
| Conditioning of Asphalt Mixtures (Aging) [1, 2] | | R 30 |
| Preparing Gyratory Samples [1, 2, 3] | | T 312 |
| Asphalt Cement Drain Down [1, 2] | | D 6390 |
| Splitting & Quartering Samples [1, 2] | DOTD TR 108 | |
| Reducing Samples of Asphalt Mixtures to Testing Size [1, 2, 3] | | R 47 |
| Sieve Analysis of Fine & Coarse Aggregate [1, 2] | DOTD TR 113 | T 27/C 136 |
| Determination of Moisture Content (Stockpile Aggregates) [1] | DOTD 403 | T 255/C 566 |
| Amount of Material Finer than the 75 µm (# 200) Sieve in Aggregate by Wash [1, 2, 3] | DOTD TR 112 | T 11/ C 117 |
| Mineral Matter or Ash in Asphalt Materials using Centrifuge or Reflux Extraction of Asphalt Cement for reporting %AC | DOTD TR 314M | T 111 |
| Fine Aggregate Angularity [2, 3] | DOTD TR 121 | T 304/C 1252 |
| Flat & Elongated Particles [2, 3] | | D 4791 |
| Sand Equivalent [2, 3] | DOTD TR 120 | T 176/D 2419 |
| Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures [2, 3] | | T 324 |
| Superpave Volumetric Mix Design [2] | | M 323 |
| Stone Matrix Asphalt (SMA) Mix Design [2] | | M 325 |
| Moisture Sensitivity (Lottman – Tensile Strength Ratio) [2] | DOTD TR 322 | T 283/D 4867 |
| Coarse Aggregate Bulk Specific Gravity & Absorption [2, 3] | | T 85 |
| Fine Aggregate Bulk Specific Gravity & Absorption [2, 3] | | T84 |

[1] Asphalt Production Laboratories.

[2] Asphalt Mix Design Laboratories.

[3] DOTD District Laboratories.

# Chapter II. Independent Quality Assurance Program

## A. INTRODUCTION

INDEPENDENT ASSURANCE PROGRAMS
A system based IA Program for asphalt materials will be employed which includes the maintenance of accreditation by all laboratories and maintenance of certification and proficiency of all certified technicians. System independent assurance will include random plant and field visits to view test performance, verification of the calibration of equipment and examination of the accreditation records.

Independent Assurance, is required for National Highway System (NHS) federal funding. FHWA Technical Brief FHWA-HIF-12-001 describes Code of Federal Regulations 23CFR637 that addresses the evaluation necessary for FHWA requirements.

DOTD has changed to "System Approach" for Independent Assurance where qualifications of involved personnel and facilities are assessed.

INDEPENDENT ASSURANCE

For HMA materials, the following proficiency tests will be required:

**Proficiency Sample Testing**

| Asphalt Samples | Tests | Frequency |
|---|---|---|
| Gyratory Briquettes, | Gmb, Voids | Minimum 1 per year |
| Loaded Wheel Test (Level 2 certification only) | AASHTO 324, Rut depth | Minimum 1 per year |
| Oven Extracted Gradation | %AC and % Passing each sieve. | Minimum 1 per year |
| Loose Mix | Rice Gravity, $G_{mm}$ | Minimum 1 per year |

Satisfactory performance for participants in the proficiency program will be test results less than 2 standard deviations from the mean.

System Independent Assurance Team:

A system independent assurance team will be housed at the Training/IA lab at the Materials Lab and the personnel will be comprised of the Field Quality Assurance Engineer, the **independent assurance engineer**, and assurance technician(s). The lead certified technician in each District will also be responsible for assisting with the IA duties. The team will perform the following:

- **I.** **Material Quantity Report:** Annual Summary Report by district, by plant, by project, technician to collect input data monthly.
- **II.** **Individual Lab review. each** district lab, annually
  - **a.** Personnel and Equipment

b. Lab Data

III. **Proficiency Sample Report,** semi-annual report presentation of proficiency sample program,

IV. **Accreditation/Certification report: Summary, annually** Report a listing all accredited labs, and dashboard of accreditations and equipment. (monthly Input by technician) (Engineer)

V. **Dispute Resolution and Forensic analysis and other requests:** When needed the IA team may be called upon to perform dispute resolution, forensic analysis and/or technical assistance. Any of the nine District Laboratories or the contractors certified laboratory may be used at the direction of the Field Quality Assurance Engineer. The Engineer and Technician(s) will provide technical expertise, documentation, and test reports to assist the DOTD in the dispute resolution(s) and forensic analysis as needed.

# PART 2 – DESIGN, PRODUCTION, AND ACCEPTANCE

## Chapter III. Section 501 – Thin Asphalt Concrete Applications

This chapter describes the procedures and documentation required for designing, validating, and producing an Asphalt concrete mixture for use on a DOTD project while applying Section 501 of the *Standard Specifications* (Thin Asphalt Concrete Applications). It also details Plant Quality Control and Acceptance, Roadway Quality Control and Acceptance, and How to Pay for Asphalt Mix.

This chapter shall be used in conjunction with Section 502 (Asphalt Concrete Mixtures) and Section 503 (Asphalt Concrete Equipment and Processes) of the Standard Specifications. However, information in this chapter also applies to Section 1002 (Asphalt Materials and Additives) and Section 1003 (Aggregates).

The District Laboratory will verify the contractor's values of stockpile bulk specific gravities, absorption, and consensus properties. Verification of contractor stockpiles for water absorption of 2.0% or less will be required for aggregates per 501.02.4 of the Standard Specifications by the District Laboratory.

Applicable test procedures are listed in Table 502-1 of the Standard Specifications. A copy of the following shall be available at the production facility:

Contract documents
Current edition of the Standard Specifications
Material Sampling Manual
All applicable testing procedures
Approved Materials List
JMF
R18 Documentation

Section 501 Mixtures specifications differ from Section 502 in the methods and testing as describe here in.

### A. Mix Design Steps and Approval

#### 1. Material Procurement and Approval

Material procurement and approval procedures are the same as for Section 502 except the contractor will submit a Certificate of Analysis showing aggregate properties conforming to Table 501-2 and subsection 501.02.4.

#### 2. Aggregate

**Coarse Aggregate -** Coarse aggregates for use in Thin Lift Asphalt Concrete shall be listed in Approved Materials List and meet the requirements of Subsections 1003.01 and 1003.06. The combined aggregates shall be in accordance with the design gradation requirements in Table 501-3

Friction requirement shall meet requirement of table 501-2

**Fine Aggregate -** Fine aggregates for use in Thin Lift shall be from aggregate sources listed in Approved Materials List and meet requirement of Table 501-2. The Fine Aggregate Angularity (FAA) of each fine aggregate source shall be measured and the calculated average blend (AASHTO T-304) or weighted average of individual components shall be measured in accordance with DOTD TR 121 (mineral filler excluded).

3. Asphalt Cement

**Asphalt Cement –** Asphalt cement shall be from an approved source listed in Approved Materials List. Asphalt cement grade shall be in accordance with Table 501-1. Substitutions will be allowed in accordance with Section 501.02.2.

Asphalt cement is accepted at the plant, by a Certificate of Delivery (CD). A Certificate of Delivery shall accompany each load delivered to the plant. Asphalt cement testing shall be in accordance with Section 502.

4. Additives

**Additives –** Anti-strip or hydrated lime (if used) shall meet the requirements of Section 501.02.3., and mineral filler (if used) shall meet the requirements of Section 501.02.5

Cellulose or mineral fibers, pre-approved by the Department, shall be used to prevent drain down as needed. The specific requirements for fibers are listed in Subsections 501.02.6 and Section 1002.02.5.

## B. Design of Asphalt Mixture, Job Mix Formula (JMF)

Mix design steps and approval process are the same as for Section 502. Except for the following requirements:

1. Determination of Gradation and Bulk Specific Gravity ($G_{sb}$) for Aggregates

Procedures used to determine bulk specific gravity ($G_{sb}$) and gradation are the same as for Section 502, except that the gradation shall be as specified in Table 501-3. Ensure aggregates meet requirement of Table 501-2 ie check certificate of analysis (CA) for Micro-Deval and meet aggregate requirement of 502, 1003.01, and 1003.06

2. Blending Aggregates to Meet Specified Gradation

This procedure is the same as for Section 502.

3. Design of Blended Aggregates for Travel Lane Wearing Courses

a) *Dense, Coarse, and OGFC Mixtures*

This compaction procedure is the same as for Section 502, except that the Gyratory $N_{design}$ revolutions will be in accordance with Table 501-1.

b) *Additional Requirements for OGFC Mixtures*

To ensure stone-on-stone contact of the aggregate blend, the following method shall be used when designing Thin Lift OGFC mixtures.

For best performance, the OGFC mixture must have a coarse aggregate skeleton with stone-on-stone contact. The stone skeleton is that portion of the total aggregate blend retained on the No. 4 sieve. The condition of stone-on-stone contact within an OGFC mixture is defined as the point at which the percent voids of the compacted mixture is less than the VCA of the coarse aggregate in the dry-rodded test in accordance with ASTM Test Method C29/C29M.

The VCA of the coarse aggregate only fraction ($VCA_{DRC}$) is determined by compacting the stone with the dry-rodded technique according to ASTM Test Method C29/C29M. When the dry-rodded density of the coarse fraction has been determined, the $VCA_{DRC}$ can be calculated using the following equation from ASTM Test Method C29/C29M:

$$VCA_{DRC} = \frac{G_{CA}\gamma_w - \gamma_s}{G_{CA}\gamma_w} x100$$

where,

GCA = Bulk specific gravity of the coarse aggregate

$\gamma_s$ = Bulk density of the coarse aggregate fraction in the dry-rodded condition,

$\gamma_w$ = Density of water

$V_a$, and $VCA_{MIX}$:

- Select three trial blends of aggregate within the aggregate gradation bands as detailed in Table 501 - 3, "JMF Extracted Gradation and Production Tolerances".
- Determine the dry-rodded voids in the coarse aggregate, retained on the No. 4 (4.75 mm) sieve, of the coarse aggregate only, $VCA_{DRC}$ as described above.
- Add between 6.5% to 7.0% asphalt cement to each trial blend and compact blend to 50 gyrations in a Superpave gyratory compactor. (Note: At this stage of design, fiber should be added at the manufacturer's recommended rate. Fibers are required only if the drain down requirements are not met. Typical fiber rates are 0.2% to 0.5% of the total weight (mass) of the mix.)
- Determine the percent air voids ($V_a$), and percent voids in the coarse aggregate for each of the compacted mixes ($VCA_{MIX}$).
    - Determine the bulk specific gravity of the mix ($G_{mb}$), using AASHTO T 166, the physical volume or vacuum sealing test method AASHTO T 331.
    - Determine the theoretical maximum specific gravity of the mixture ($G_{mm}$), in accordance with DOTD TR 327.
    - Determine the bulk specific gravity of the coarse aggregate fraction ($G_{CA}$), in accordance with ASTM C 127.
    - Calculate $V_a$, and $VCA_{MIX}$ using the following equations:

$$V_a = 100 \times \left(1 - \frac{G_{mb}}{G_{mm}}\right)$$

$$VCA_{MIX} = 100 - \left( P_{CA} \times \frac{G_{mb}}{G_{CA}} \right)$$

Where,

$P_{CA}$ = percent coarse aggregate in the total mixture
$G_{mb}$ = bulk specific gravity of the compacted mixture
$G_{mm}$ = theoretical maximum specific gravity of the mixture
$G_{CA}$ = bulk specific gravity of the coarse aggregate fraction

- Select the aggregate gradation blend that achieves a minimum 18% air voids ($V_a$).
- To determine the optimum percent of asphalt in the mixture prepare two additional mixtures using 0.5% and 1.0% additional asphalt cement using the desired aggregate blend as selected previously and compact using 50 gyrations of the Superpave gyratory compactor. The optimum percent of asphalt will be determined based on specification compliance for percent air voids and asphalt cement draindown. The percent $VCA_{MIX}$ shall be reported for information.
- For design, the asphalt cement draindown test shall be conducted in accordance with ASTM D 6390 on the loose mix at a temperature 50°F (10°C) higher than normal mixing temperatures. A maximum 0.3% draindown of asphalt cement by weight (mass) will be allowed. Draindown will be in accordance with Table 501-1.
- For Coarse Graded and OGFC mixes use the Physical Volume (if voids are ≥10%) or Vacuum Sealed method for calculating voids.

Open or coarse asphalt mixtures may be tested for voids using ASTM D 3203 (Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures) (Physical Volume) if voids are greater than 10.0% or water absorption is greater than 2.0%. They may also be tested using AASHTO T 331, (Bulk Specific Gravity and Density of Compacted Hot Mix Asphalt Using Automatic Vacuum Sealing Method)

Calipers will be used for measurements used in calculating volume.

Four measurements for thickness will be at approximately quarter points along the periphery of the gyratory. Average the four measurements for height for use of calculations. Make two measurements perpendicular to each other (for a total of four) on both flat surfaces and average for diameter of the gyratory.

An example for measuring voids using Physical Volume is as follows:

3915.0g = Dry weight of gyratory

2.355 = $G_{mm}$ of mix

150.0mm = Averaged diameter of gyratory

Radius (*r*) = 150mm (diameter) ÷ 2 = 75mm

115.0mm (*h*) = Averaged height of gyratory

$\pi$ = 3.1416

.99707 = factor to convert from density (g/cm3) to bulk specific gravity ($G_{mb}$)

$v$ = volume

$V_a$ = voids

$h$ = height of gyratory sample

Volume of a cylinder (gyratory), $v = \pi r^2 (h)$

$(3.1416)(75.0\text{mm}^2)(115.0\text{mm}) = v\ \text{mm}^3$

$(3.1416)(5625)(115.0) = 2032222.5\ \text{mm}^3 \times 0.001$ (convert $\text{mm}^3$ to $\text{cm}^3$) $= 2032.222\underline{5}\ \text{cm}^3$

Spreadsheet rounded to 2032.223 (two places past the final answer)

Density of the gyratory sample = mass (g) ÷ volume ($v$)

$3915\text{g} \div 2032.223\text{cm}^3 = 1.92\underline{6}$ grams per cubic centimeter ($\text{g/cm}^3$)

$1.926 \div .99707 = 1.93\underline{2} G_{mb}$ Converts from density to bulk specific gravity

$100 – [100\ (G_{mb} \div G_{mm})]$ = Percent voids in gyratory sample

$100 - [100\ (1.932 \div 2.355)] = V_a$

$100 – [100 \times .82\underline{0}38] = V_a$

$100 – 82.0 = V_a$

$18.0 = V_a$

4. Trial Blends with Varying Asphalt Cement Contents (Except OGFC)

Refer to Chapter IV, Section 502: *Trial Blends with Varying Asphalt Cement Contents* of this manual.

5. Selection of Optimum Asphalt Cement Content

Conform to requirements of Table 501-1. Refer to Chapter IV, Section 502: *Selection of Optimum Asphalt Cement Content* and Table 501-01 to determine optimum values.

6. Dust to Effective Asphalt Cement Ratio Evaluation. Dust to Effective Asphalt Cement Ratio does not apply to the 501 spec unless otherwise stated.

7. Moisture Sensitivity Analysis

a) *LWT, Loaded Wheel Test, (AASHTO T324)*

Contractor will submit LWT results for specimens indicating conformance to Table 501-1. LWT may be tested at the plant laboratory when witnessed by the ADI or using the district laboratory LWT equipment.

After validating the approved JMF proposal for mix properties, the contractor, witnessed by the Department, shall sample the next production lot and perform validation testing at the plant for LWT specimens (Production will be allowed to continue). Samples for DOTD LWT verification will also be made and sent to the district lab. Results will be forwarded to the district laboratory engineer. When the validation results are not in conformance with specification requirements, no further production for that job mix formula will be accepted on any DOTD project.

8. Submittal Process and Documentation - JMF Proposal Form and Approval of JMF Proposal

The process for submittal and approval of JMF Proposal are the same as for Chapter IV, Section 502: *Submittal Process and Documentation*.

9. Approval of JMF Proposal

Refer to Chapter IV, Section 502: *Approval of JMF Proposal*.

10. Validation of JMF Proposal

Validation procedures shall be in accordance with Subsection 501.05.

In accordance with Section 501.04, a lot is defined as one segment of continuous production of asphalt concrete mixture from the same JMF produced for the Department at a specific plant, delivered to a specific project.

Validation Lot of 1200 tons comprised of three 400 ton sublots. Test each sublot as follows:

- 1 – aggregate gradation and percent asphalt cement
- 1 – briquettes tested for volumetrics ($V_a$),
- 1 - corresponding Maximum Theoretical Specific Gravity ($G_{mm}$).

In addition, for the validation lot, take

- 1 – asphalt cement draindown
- 1 – percent anti-strip additive
- 1 – Boil Test

a) *Water Susceptibility, Boil Test TR-317*

One Water Susceptibility of Asphaltic Concrete Materials, TR317 will be performed on the first production lot after validation at the plant laboratory and if questionable thereafter.

b) *LWT (Rut Testing) Validation of JMF Proposal*

Pending acceptable validation results, moisture sensitivity testing (LWT testing) shall be performed the next day in accordance with Chapter IV, Section 502: *LWT (Rut Testing) Validation of JMF Proposal*. (A minimum of four roadway cores including the top lift of the underlying surface may be used for LWT testing.)

Once completed, the validation data is promptly forwarded to the district laboratory engineer, the average gradation and $G_{mm}$ measured during validation will be become the JMF targets as per Table 501-4.

**The average of test results shall meet 100% pay requirements in Table 501-5 for job mix validation and final job mix formula approval, and the individual test result must meet the tolerances of Table 501-4.** If the mix fails to validate, one additional attempt may be allowed by the District Laboratory Engineer before requiring redesign of the mixture.

Upon validation of the JMF, the validation results shall be used for acceptance. The average of the validated results will become the JMF targets.

**NOTE:**

Individual tests must meet the tolerances of Table 501-4. For validation, if one sublot does not meet the tolerances in table 501-4, the contractor may exclude that sublot from the validation provided adjustments are made to the mix. The validation tonnage shall be extended to include a fourth sublot and tests. The tonnage for the excluded validation sublot will be paid according to table 501-5 and paid as a separate lot.

The department will also evaluate the performance of the mixture on the roadway to ensure that the JMF is not contributing to laydown deficiencies, such as segregation, tenderness, workability, or surface texture problems. Mixtures that are identified as causing any laydown deficiency will not be approved. The project engineer or the district laboratory engineer may reject a proposed JMF due to roadway deficiencies.

c) *Failure to Validate*

If a mixture design fails to validate, a second validation attempt will be allowed. If a validation fails, a new proposal must be submitted and validation testing repeated or the producer may use a previously approved Job Mix Formula. No mixture shall be produced for a DOTD project until the DLE has approved a new JMF proposal. If the JMF does not validate, the DLE will indicate disapproved on the proposed JMF Proposal, enter the sequence number, date and sign it (Disapproved). Copies of the disapproved JMF Proposal will be distributed to each project engineer who received a portion of the lot.

If the JMF proposal does not meet requirements or does not validate, the district laboratory engineer will indicate disapproved on the proposed JMF, enter the sequence number, date, and sign it (Disapproved). Copies of the disapproved JMF Proposal will be distributed to each project engineer who received a portion of the lot.

11. Final Approval of JMF

After meeting Validation requirements of Tables 501-3 and 501-4, 100% pay per table 501-5, and satisfactory roadway laydown and performance, the DLE may make final approval. The validation averages shall become production targets.

## C. Definition of a Lot

Standard lot size is 2400 tons comprised of 3 – 800 ton sublots in accordance with Section 501.04.

> **NOTE:**
>
> The final lot of the project may be increased to 3600 tons with mutual agreement of the contractor and Project Engineer.

## D. Plant Quality Control

General requirements are the same as for Section 502, except that draindown must be performed sufficiently to ensure that the mixture is within specification limits. Percent asphalt cement, gradation, $G_{mm}$, and air voids shall be measured in accordance with Section 501. Sampling and testing requirements are as specified in the Materials Sampling Manual.

The sample requirements for each sublot shall be as follows:

- Air void contents
- Theoretical Maximum Specific Gravity Tests, $G_{mm}$
- Asphalt content determinations
- Extracted gradations
- Coarse Aggregate Angularity determinations

One LWT per 10,000 tons per JMF (four gyratory specimens).

If the average tests for the lot are not within specification requirements, corrections shall be made or operations ceased. These values are recorded along with other contractor/producer data within the DOTD data system.

This specified Quality Control Program is a minimum requirement and should not prevent the technician from performing any test(s) to ensure consistent production, meeting specifications.

The asphalt cement content is based on the Ignition Oven (TR 323) results along with a correction factor. The correction accounts for moisture, fibers, and loss of aggregate during ignition. For additional information, the rate of asphalt cement delivery is continuously shown, in digital form, on all modern plant controls. If the delivery rate of asphalt cement plus the asphalt credit from RAP (if used) differ by more than ±0.3% from the Ignition Oven (with correction factor) for two consecutive test, take corrective action. Corrective action can be reestablishing the correction factor, recalibrating the asphalt cement metering system or other systems of the plant. Document and forward to the DLE the cause and corrective action taken.

The Contractor shall also check the rate of anti-strip, mineral filler, lime, or fibers at the beginning of each operational period, and when necessary thereafter, to ensure that the mixture is receiving the JMF percent.

## E. Acceptance and Verification

### 1. Plant Acceptance

A Certified DOTD Inspector will perform acceptance testing for 501 mixtures.

General requirements are the same as for Section 502, except that draindown must be performed to ensure that the mixture is within specification limits. Percent asphalt cement, gradation, $G_{mm}$, and air voids shall be measured in accordance with Section 501. Sampling and testing requirements are as specified in the Materials Sampling Manual.

The sample requirements for each sublot shall be as follows:

- One Theoretical Maximum Specific Gravity Test, $G_{mm}$
- One asphalt cement content determination
- One extracted gradation
- One Coarse Aggregate Angularity determination
- For coarse and OGFC, perform one draindown test per lot
- Gyratory for $V_a$

Project Asphalt Cement sample requirements are as follows:

- One sample per shipment or Certificate of Compliance (CC) for Fibers
- One transport sample per grade per project for Asphalt Cement submitted for complete analysis.
- One working tank sample per day per grade used for 501

Verification sample requirements are as follows:

One LWT per 10,000 tons per JMF (Four gyratory specimens may be prepared by the district laboratory). The LWT may be witnessed at the plant by the ADI.

Verify aggregates are on Approved Materials List with current Micro-Deval (Note: Materials Lab tests one full sample sack per project if Micro-Deval values are in question.) Flat and Elongated and CAA should be part of the six month or new source stockpile samples.

Verify Anti-Strip additive quantity from meter each production day.

If the average tests for the lot are not within specification requirements, corrections shall be made or operations ceased. These values are recorded along with other contractor/producer data within the DOTD data system.

2. Roadway Acceptance

The tack coat application rate shall be verified during the first day production.
Tack coat rate will be measured and calculated for proper application rate. Tack coat Visual acceptance will be in addition to measurable criteria.

For surface tolerance see Chapter V – Surface Tolerance and Table 501-6 in the Standard Specifications.

High AC content thin lift mixes may need adjustment factors to adjust for yield and payment.

3. Plant Verification

The district laboratory will verify the contractors aggregate bulk specific gravities, absorptions, and consensus properties every six months.

When AC is questionable, send one roadway core to Materials Lab for analysis

District Laboratory Verification testing per production lot is as follows:

- One loose mix for $G_{mm}$ testing
- One gyratory specimen prepared at $N_{design}$ and subsequent $V_a$, VMA, and VFA volumetric calculations. (With the exception of OGFC mixtures.)
- One loose mix for asphalt extraction, gradation (No. 4 and No. 200) and percent crushed

## F. Measurement and Payment

1. Measurement

Weight measure (by the ton) will be based on Section 502. Measure the square yards paved and total gallons of tack coat applied. Report in gallons per square yards. Record tonnage received based on truck tickets as delivered to roadway.

2. Payment

Payment for Thin Asphalt Concrete mixture will be made at the contract unit price per ton. Apply pay adjustment based on Table 501-5 for $G_{mm}$, Gradation, and Tack Coat Rate. Pay adjustment is the lowest determined value.

Payment for tack coat will be made by the gallon in accordance with Section 504.

# PART 2 – DESIGN, PRODUCTION, AND ACCEPTANCE

## Chapter IV. Section 502 – Asphalt Concrete Mixtures

*This chapter describes the procedures and documentation required for designing, validating, and producing an Asphalt concrete mixture for use on a DOTD project while applying Section 502 of the Standard Specifications (Asphalt Concrete Mixtures). It also details Plant Quality Control and Acceptance, Roadway Quality Control and Acceptance and How to Pay for Asphalt Mix.*

This chapter shall be used in conjunction with Section 502 (Asphalt Concrete Mixtures) and Section 503 (Asphalt Concrete Equipment and Processes) of the Standard Specifications. However, information in this chapter also applies to Section 1002 (Asphalt Materials and Additives) and Section 1003 (Aggregates).

Applicable test procedures are listed in Table 502-1 of the Standard Specifications. A copy of each applicable test procedure shall be available at the plant for immediate reference. The Preface contains a listing of appropriate manuals.

Warm Mix Asphalt, (WMA) is defined as asphalt concrete mixture that is modified by approved foaming methods or chemical additives to reduce mixing and compaction temperatures.

### A. Mix Design Steps and Approval

#### 1. Material Procurement and Approval

The contractor selects and procures materials to utilize in the mix design process. Materials for an Asphalt mix design include, but are not limited to aggregates, asphalt cement and anti-strip.

**Source Approval** – All materials are assigned an approved brand name or on the Approved Materials List (AML).

a) *Aggregate*

All aggregates will be submitted to the district laboratory for verification.

**Stockpile Samples** – Stockpile samples are to be tested for verification of contractor's submitted values every six months. Samples for new sources are to be submitted at **least three weeks prior to the submission of a job mix proposal (JMF).** No proposed JMF will be accepted until all mix components have been approved. For specific stockpile materials that test within $G_{sb}$ tolerances and consensus properties for three consecutive test cycles (18 months), sampling frequency may be extended to 12 months with the approval of the DLE. RAP is excluded from frequency extension.

Qualification requirements for coarse aggregate and fine aggregates will comply with section 1003.06 and 502.02.3 Aggregates. Plus No. 4 material is considered coarse aggregate and minus No. 4 material is considered fine aggregate. If more than 10% material passes the No. 4 of a primarily coarse material or more than 10% material is retained on the No. 4 of a primarily fine material, tests for both coarse and fine aggregate will be performed respectively. Aggregates that are tested for fine and coarse properties will be mathematically combined for a single value.

Blended aggregates shall comply with Table 502-6 Asphalt Concrete General Criteria and Table 502-4 Plant Produced Asphalt Mixture Requirements and Tolerances.

Reclaimed Asphalt Pavement (RAP) will be allowed in 502 mixtures at specified percentages. The aggregate portions of RAP will be tested for fine and coarse $G_{sb}$. Working stockpiles of RAP must be verified by the District Lab, receiving an approved source code. RAP shall be cold planed in accordance with Section 509 and shall meet the requirements of Section 1003.

The Percent Moisture, Asphalt Content, Gradation, aggregate absorption, and aggregate $G_{sb}$ of RAP shall be reported to the District Lab by the contractor when verification samples are taken.

Additional RAP is allowed in 502 mixes except for Airports and SMA when:

RAP is stockpiled separately with all material passing a 1 inch screen.

When RAP is pre-screened over the 1 inch, an additional 5% RAP can be added for mixes that allow RAP.

Mixes with the 5% additional RAP must meet all specifications and perform satisfactory.

**Friction Rating** - For travel lane wearing courses, the total aggregate combination shall comply with Table 502-3 Aggregate Friction Rating. This table specifies allowable usage according to mixture type and Average Daily Traffic, (ADT). The mixture type will be shown on the pavement typical sections in the contract plans.

b) *Asphalt Cement*

Asphalt cement will be on the AML. Asphalt cement grade shall comply with Subsections 1002 and 502.02.1 and Table 502-2 – Asphalt Cement Usage. Substitutions are allowed in accordance with Table 502-2. A Certificate of Delivery/Analysis shall accompany each load delivered to the plant. The District Laboratory will test working tank samples. The Materials Laboratory will request the District Laboratory sample transports for refinery verification samples. District Lab employees will coordinate plant production, and transport delivery with Materials Laboratory sample request.

c) *Additives*

Anti-strip shall be added to all mixtures and in an amount determined in accordance with Subsection 502.02.2.1. Anti-strip used shall be in the Approved Materials List. A Certificate of Delivery for Asphalt Anti-strip Additives shall accompany each load of anti-strip.

Hydrated lime, if used, shall be in accordance with Subsection 502.02.2.2 and from a source listed in the AML. The minimum rate shall not be less than 1.5% by weight of the total mixture. Further, hydrated lime shall be added to and thoroughly mixed with aggregates in accordance with Subsection 502.02.2.2. Hydrated lime may be also added as mineral filler in accordance with Subsection 502.02.3.3. A Certificate of Delivery shall accompany each load of hydrated lime.

Mineral filler, if used, shall be in accordance with Subsection 502.02.3.3 and Subsection 1003.06.1.6 and an approved product listed in the AML. It shall consist of limestone dust, pulverized hydrated lime, Portland cement or cement stack dust. A Certificate of Delivery, matching a format similar to the CD for Asphalt Materials, shall accompany each load of mineral filler.

Waste Tire Rubber Additive, if used, shall be blended with an AML PG 67-22 material. Add Crumb rubber as required to meet grade PG 82-22rm. Use a maximum size rubber particle of 30 mesh crumb (90-100% passing the No. 30 sieve). In accordance with 1002.02.2. Waste Tire Rubber additive will require the contractor perform DSR testing of the blended material.

Latex Additive, if used, shall be in accordance with Subsection 502.02.2.4. Latex added at the contractor's plant shall be blended at a minimum of 1.0% residual latex by weight of asphalt cement to an AML PG 67-22 material and in accordance with Section 503.05.2. Latex blended asphalt shall meet PG 70-22m specification requirements using pre-qualified asphalt material and latex. Latex additive will require that the contractor perform DSR testing of the blended material.

Fibers, if used, shall be in accordance with Subsection 1002.02.5. Fibers shall be a cellulose or mineral fiber. Fibers shall be added at a minimum rate of 0.1% by weight (mass) of mixture and at a rate sufficient to prevent draindown.

Natural sand, if used, shall be in accordance with the requirements of Table 502-6 and Section 1003.06. 3.

Warm Mix Additives, if used, shall be in accordance with Section 1002.02.4.

2. Design of Asphalt Mixture, Job Mix Formula (JMF) Listed below are the general steps required to design, validate and approve an Asphalt mixture according to Section 502. Using the material and procurement process listed above proceed with the following steps for approval of JMFs.

- *Determination of Gradation and Bulk Specific Gravity ($G_{sb}$) for aggregates*
- *Consensus aggregate tests and evaluations (Coarse Aggregate Angularity, Fine Aggregate Angularity, Flat and Elongated Particles, and Sand Equivalency)*
- *Blending of aggregates to meet specified gradation*
- *Blending aggregates to meet friction rating requirements for travel lane wearing courses*
- *Trial blends with varying asphalt cement contents*
- *Selection of optimum asphalt cement content*
- *Dust to Effective Asphalt Cement ratio*
- *Draindown analysis for SMA*
- *Moisture sensitivity (LWT) analysis*
- *Semi Circular Bend (SCB) analysis*
- *Submittal process and documentation – (JMF Proposal Form)*
- *Approval of JMF Proposal*
- *Validation of JMF Proposal*
- *Final Approval of JMF*

a) *Determination of Gradation and Bulk Specific Gravity ($G_{sb}$) for Aggregates*

(1) Gradation

The contractor shall obtain a sample from each proposed stockpile for gradation determination. An accurate gradation analysis is required for blending analysis and to determine consistency of incoming material.

It is recommended that the contractor secure samples of all bulk shipments of aggregates delivered to the plant site. The gradation results of these shipments should be determined prior to their addition to a working stockpile. Documentation of these continuous stockpile gradation and specific gravity results shall be kept on file so that varying trends of the aggregate source may be determined. The contractor shall report stockpile gradations to the DLE every six months along with $G_{sb}$, absorption, and consensus properties.

Aggregates must be handled in a manner that will not be detrimental to the final mixture. Stockpiles shall be built in a manner that will not cause segregation. Segregation can be minimized if stockpiles are built in successive layers, not in a conical shape. Constructing stockpiles in layers enables different aggregate fractions to remain evenly mixed and reduces the tendency of large aggregates to roll to the outside and bottom of the pile. Stockpiles shall be located on a clean, stable, well-drained surface to ensure uniform moisture content throughout the stockpile. The area in which the stockpiles are located shall be large enough for the stockpiles to be separated, so that no intermixing of materials will occur. Stockpiles shall not become contaminated with deleterious materials such as clay balls, leaves, sticks or non-specification aggregates. The materials shall not become contaminated nor segregated when they are transported from stockpiles to cold feed bins. Aggregates are often moved from stockpile to cold feed bin with a front-end loader. The operator should proceed directly into the stockpile, load the bucket and move directly out, and should not scoop aggregate from only the outside edges of the stockpile.

(2) Bulk Specific Gravity ($G_{sb}$)

Coarse aggregate will be defined as material retained on the No. 4 sieve.
Fine aggregate will be defined as material passing the No. 4 sieve.
Coarse aggregate stockpiles are defined as when >50.0% of the material is retained on the No. 4 sieve.
Fine aggregate stockpiles are defined as when >50.0% of the material passes the No. 4 sieve.

Once proposed aggregate materials have been stockpiled at the plant and are approved for use, the bulk specific gravity of each mineral aggregate material shall be determined. The department will verify $G_{sb}$ using verification samples from each proposed aggregate stockpile. The contractor shall test a sufficient number of samples to ensure consistency of their stockpiles.

Use AASHTO Test Procedure T 84 to determine bulk specific gravity ($G_{sb}$) and absorption for each proposed fine aggregate source. Note that fine aggregate is defined in the *Standard Specifications* as all material passing the No. 4 sieve. When a primarily fine stockpile material has more than 10% retained on the plus No. 4 sieve, both T84 and T85 shall be performed. The Material tested for $G_{sb}$ shall be *washed over the No. 200 sieve. The after wash gradation should have less than 4% passing the No. 200 sieve.

*Note: AASHTO T84 X1.1

When a stockpile material has 20% or greater passing the No. 200, the sample shall be dry sieved over the No. 50 sieve. T84 will be used for the $G_{sb}$ and absorption of the minus No. 4 to the plus No. 50. An Apparent Gravity will be run on the minus No. 50 material. DOTD TR 300 method B will be used to determine the Apparent Gravity. Modifications to DOTD TR 300 are as follows:

> Sample size: 250 g ± 10g
> Vacuum is to be gradually increased (to prevent foaming into the neck) up to 27.5mm Hg ± 2.5mm Hg. Vacuum for 1 minutes 30 seconds after foaming begins not to exceed 27.5mm Hg ± 2.5mm Hg.
> An alternate to vacuuming is to **gently** boil the sample on a hot plate for 30 minutes.

The Apparent Gravity of the minus No. 50 material shall be mathematically combined in proportion to the $G_{sb}$ of plus No. 50 and minus No. 4 material. Absorption will be that of the minus No. 4 and plus No. 50.

Use AASHTO Test Procedure T 85 to determine bulk specific gravity ($G_{sb}$) and absorption for each proposed coarse aggregate source. Note that coarse aggregate is defined in the *Standard Specifications* as all material retained on or above the No. 4 sieve.

For aggregate sources which are primarily coarse and contain ten percent or less material by weight passing the No. 4 sieve, a bulk specific gravity ($G_{sb}$) determination on that passing portion will not be required. However, should the proposed aggregate stockpile contain more than ten percent passing the No. 4 sieve, then the finer portion shall be separated and tested in accordance with AASHTO T 84. The results, for both coarse and fine portions, shall then be mathematically combined in proportion to the amounts retained on the No. 4 and passing the No. 4 to produce a single $G_{sb}$ value for the source. The bulk specific gravity ($G_{sb}$) is used to calculate VMA and asphalt absorption. False high values for $G_{sb}$ will lead to false high VMA's and negative asphalt absorptions. If negative asphalt absorptions are calculated, the $G_{sb}$ is in error. When this is observed, the DLE shall investigate.

The contractor may use the calculated (weighted average) values for bulk specific gravity ($G_{sb}$) on the proposed JMF provided each individual aggregate tested value are within the following range when compared to the district laboratory's values. These values were determined from multi-laboratory precision analysis.
The DLE is responsible for collecting data for each verification stockpile sample tested by the contractor and District Lab independently.

**Bulk Specific Gravity Tolerances**

| **Multi-Laboratory Precision for Bulk Specific Gravity ($G_{sb}$)** | |
|---|---|
| | **$G_{sb}$** |
| Fine Aggregate | ±0.030 |
| Coarse Aggregate | ±0.020 |

Should the contractor's values be outside this range when compared to the district laboratory, then both parties shall jointly run a third test and these results shall be used for volumetric calculations on the proposed JMF submittal.

Bulk specific gravity values agreed upon by this procedure may be used on subsequent job mix formula submittals. The bulk specific gravity ($G_{sb}$) may be retested at the discretion of the DLE. If bulk specific gravity ($G_{sb}$) results of the retest are within the tolerances shown above when compared to the previously determined values, the contractor has the option of using the new values or the ones previously established and used on approved, validated JMF's.

At the option of the contractor/producer or DOTD, if the proposed composite aggregate blend is already known, the bulk specific gravity ($G_{sb}$) may be performed on a composite belt sample, separating the fine and coarse portions, in lieu of performing the $G_{sb}$ procedure on each individual aggregate.

**RAP must be dried in accordance with DOTD TR323 prior to testing.**

RAP %AC will be determined in the ignition furnace per TR 323. The correction factor from TR 323 IV.D.1.c will be deducted from the %AC obtained from the furnace extraction %AC. As an alternate, TR 307 or TR 308 may be used to determine %AC along with a mineral matter correction using TR 314. Mineral matter correction will be performed for each round of testing if fluid extraction is utilized. RAP samples used for determination of %AC shall be dried to constant mass before testing with a tolerance of 0.3% AC content between the contractor and the District Laboratory. Aggregate from the determination of %AC will be sieved into coarse (plus No. 4) and fine (minus No. 4) fractions. AASHTO T85 and T84 will be used to determine the Bulk Specific Gravity and Absorption of the RAP aggregate. The results, for both coarse and fine portions, shall be mathematically combined in proportion to the amounts retained on the No. 4 and passing the No. 4 to produce a single $G_{sb}$ and absorption value for the source. $G_{sb}$, %AC and absorption will be verified by the DOTD District Lab when conducting six month stockpile sample verification. Verification of RAP values may be retested at the discretion of the DLE Contractors that fractionate RAP shall stockpile and test separately. The District Lab shall test stockpiles intended for use in state projects accordingly.

The minus No. 4 aggregate from RAP will be washed over the No. 200 sieve before testing for $G_{sb}$.

When determining the composite gradation for mixtures containing RAP, consider the RAP aggregate as an aggregate source, so that the total aggregate percentages, including RAP aggregate equal 100%.

b) *Consensus Aggregate Test Evaluations*

The consensus aggregate tests determine properties of aggregates that are expected to contribute to the performance within HMA pavements. The consensus tests are listed below:

a) Coarse Aggregate Angularity (DOTD TR 306 – Double Face)

b) Fine Aggregate Angularity (DOTD TR 121)
c) Flat and Elongated Count (ASTM D 4791)
d) Sand Equivalency (DOTD TR 120)

There are required specifications for these aggregate properties. They are listed in Table 502-6. They are based on traffic level and position within the pavement structure. Materials near the pavement surface subjected to high traffic require more stringent consensus property specifications. They are intended for application to a proposed aggregate blend, not to individual components. However, they may be run on individual aggregate sources and mathematically combined. Individual components may be tested so that poor materials may be identified.

(1) Coarse Aggregate Angularity - (CAA)

CAA is required for all aggregates having 10% or more retained on the No. 4 sieve. Aggregates not meeting this criterion are ignored in the coarse aggregate angularity calculations for the blend.

CAA is determined in accordance with TR 306 (Double Faced) on the coarse material retained on the No. 4 sieve. This test ensures a high degree of aggregate internal friction and rutting resistance. [The minimum values for this test are given in Table 502-6 for each Level, type of mix and nominal maximum size (NMS) aggregate.]

The district laboratory will verify the CAA value. Should the district laboratory's results be within ±3 percent of the result reported on the JMF and within specification limits, then the contractor's result may be used. If not, the contractor shall run a third sample jointly with the district laboratory engineer's representative. The contractor shall use this jointly determined value for JMF submittal.

The contractor shall determine and report individual source CAA on the JMF. The CAA of the composite mixture shall be determined by calculating the weighted average based on aggregate proportions and the individual CAA values.

When mathematically combining CAA, use the following equation:

$$C = \left(\frac{P_1}{P_T} \times A_{p1}\right) + \left(\frac{P_2}{P_T} \times A_{p2}\right) + \left(\frac{P_3}{P_T} \times A_{p3}\right)$$

| | |
|---|---|
| C | = Composite, CAA |
| P1, P2, P3, | = % Aggregate From Cold Feed Used for Consensus Properties |
| PT | = Total of % Aggregate Used for Consensus Properties |
| Ap | = Aggregate CAA Properties |

(2) Fine Aggregate Angularity - (FAA)

FAA is required for all aggregates having 10% or more passing the No. 4 sieve. Aggregates not meeting this criterion are ignored in the fine aggregate angularity calculations for the blend. To calculate the fine aggregate angularity for a blend, use a weighted average based on the percentages of each aggregate in the blend that meets the above criteria.

Fine Aggregate Angularity is determined in accordance with DOTD TR 121 using the bulk specific gravity, ($G_{sb}$), of the aggregate washed over the No. 200 sieve. This property ensures a high degree of fine aggregate internal friction and rutting resistance. Higher void content means more fractured faces. (The minimum values for this test are given in Table 502-6 for each level, type of mix and NMS size.)

The district laboratory will verify this value. Should the district laboratory's results be within ±1% of the result shown on the JMF and be within specification limits, then the contractor's result may be used. If not, the contractor/producer shall then run a third sample jointly with the district laboratory engineer's representative. The contractor shall use this jointly determined value for the proposed JMF.

Although the individual source (FAA) is reported on the JMF, the FAA of the composite mixture shall be determined by calculating the weighted average based on aggregate proportions and the individual FAA values reported on the JMF. The contractor shall determine this FAA composite value (and for any individual source values) and report it on the proposed JMF.

When mathematically combining FAA use the following equation:

$$C = \frac{P_1\left(\%P_{1\#8} - \%P_{1\#100}\right)Ap_1 + P_2\left(\%P_{2\#8} - \%P_{2\#100}\right)Ap_2}{P_1\left(\%P_{1\#8} - \%P_{1\#100}\right) + P_2\left(\%P_{2\#8} - \%P_{2\#100}\right)}$$

| | |
|---|---|
| C | = Composite FAA |
| P1, P2, | = % Aggregate From Cold Feed Used for Consensus Properties |
| %P1 #8 & %P2 #8 | = % Passing No. 8 |
| %P1 #100 & %P2 #100 | = % Passing No. 100 |
| Ap | = FAA Aggregate Properties |

There may be aggregate sources that have 10% or more passing the No. 4 sieve, but because of the overall gradation, it may not be practical to obtain enough material to perform FAA. It will be at the discretion of the DLE to perform FAA on such stockpiles.

(3) Flat and Elongated - (F&E)

The count of flat and elongated particles, (F&E), is required for all aggregates having 10% or more retained on the No. 4 sieve. Aggregates not meeting this requirement are ignored in the F&E particles calculation for the blend.

Flat and elongated is determined in accordance with ASTM D 4791 using the coarse aggregate portion retained on the No. 4 sieve. This characteristic is the percentage by weight of coarse aggregates that have a maximum to minimum dimension greater than five to one. Elongated particles are undesirable because they have a tendency to break during construction and under traffic. The maximum values for this test are given in Table 502-6.

The district laboratory will verify this value. Should the district laboratory's results be within ±1% of the result shown on the JMF and be within specification limits, then the contractor/producer's result may be used. If not, the contractor/producer shall run a third sample jointly with the district laboratory engineer's representative. The contractor shall use this jointly determined value for JMF submittal.

Although the individual source results for flat and elongated particles are reported on the JMF, the F&E of the composite mixture shall be determined by calculating the weighted average based on aggregate proportions and the individual F&E values. The contractor shall determine this F&E composite value (and any individual source values) and report it on the proposed JMF.

When mathematically combining F&E, use the following equation:

$$C=\left(\frac{P_1}{P_T}\times A_{p1}\right)+\left(\frac{P_2}{P_T}\times A_{p2}\right)+\left(\frac{P_3}{P_T}\times A_{p3}\right)$$

| | |
|---|---|
| C | = Composite, F&E |
| P1, P2, P3, | = % Aggregate From Cold Feed Used for Consensus Properties |
| PT | = Total of % Aggregate Used for Consensus Properties |
| Ap | = Aggregate F&E Properties |

(4) Sand Equivalent - (SE)

Sand Equivalent is required for all natural sands, having 10% or more passing the No. 4 sieve and less than 25% passing the No. 200 sieve. Aggregates not meeting these two criteria is ignored in the sand equivalent calculations. Sand equivalency requirements shall apply to **individual natural sand sources only and do not apply to manufactured fines or fines produced from crushing operations** (e.g., screenings, No. 10's and No. 11's). Subsection 1003.06.3 provides additional specifications for natural sand. (The minimum values for this test are given in Table 502-6 for each level, type of mix, and NMS size.)

SE, sometimes referred to as clay content is determined in accordance with TR 120, using the fine aggregate portions of the composite blend (natural sands only) passing the No. 4 sieve. Clay content is the percentage of clay material contained in the aggregate fraction passing the No. 4 sieve.

The contractor shall determine the SE value for each individual natural sand used, and the SE composite value, and report them on the proposed JMF. The district laboratory will verify this value. The district lab's results must meet specification limits. If not, the contractor/producer shall then run a third sample jointly with the district laboratory engineer's representative. The Contractor shall use this jointly determined value for JMF submittal.

When mathematically combining SE, use the following equation:

$$C = \left( \frac{P_1}{P_T} \times A_{p1} \right) + \left( \frac{P_2}{P_T} \times A_{p2} \right)$$

| | |
|---|---|
| C | = Composite SE |
| P1, P2, | = % of individual natural sands from the cold feed |
| PT | = % of total natural sand from the cold feed |
| $Ap_{1,}$ $Ap_2$ | = SE Properties |

**Contractor and DOTD Tolerances for Stockpile Testing**

| Test | Description | Tolerance |
|---|---|---|
| T 84 | AASHTO $G_{sb}$ of Fine Aggregate | ±0.030 |
| T 85 | AASHTO $G_{sb}$ of Coarse Aggregate | ±0.020 |
| TR 121 | Fine Aggregate Angularity (FAA) | *±1 |
| TR 306 | Coarse Aggregate Angularity (CAA) | *± 3% |
| ASTM D 4791 | Flat and Elongated (5:1) | *±1 |
| TR 120 | Sand Equivalent | *Within Specifications |

* Both DOTD district laboratory and the contractor's results must be within specification.
If the DOTD results are not within specification or tolerance, the contractor and DOTD will jointly perform the test that does not meet specification.

**NOTE:**

The aggregate source properties, $G_{sb}$, CAA, FAA, F&E, and SE must be re-verified by the District Lab personnel at least every 6 months. If material properties change beyond the allowable verification limits, the district lab engineer will disapprove the existing JMF.

c) *Blending Aggregates to Meet Specified Gradation*

Following bulk specific gravity ($G_{sb}$) determinations, gradation and aggregate consensus tests analysis, the technician must determine a master composite blend of the proposed, approved aggregates. Again, the mixture type shall be determined from the typical sections in the project plans. Table 502-4 in the *Standard Specifications* lists a nominal maximum size aggregate for each type, a specification gradation limit for each mixture type, and tolerances (±) for the proposed JMF blend.

The following definitions are used by the DOTD to determine these sizes:

- **Nominal Maximum Size (NMS) – One sieve size larger than the first sieve to retain more than 10 percent by weight of the combined aggregates.**

- **Maximum Size (MS) – One sieve size larger than the nominal maximum size.**

With the mixture type known, the contractor can begin to mathematically blend the proposed aggregates to meet the requirement of Tables 502-4. Table 502-6 – Asphalt Design General Criteria specifies the maximum percent of natural sand and RAP that are allowed in asphalt concrete mixtures. The maximum natural sand percent is determined by percent of new aggregate; the maximum percent of RAP is by percent of total mix.

Once the aggregates have been mathematically blended to meet requirements of Section 502, the composite gradation is plotted on the appropriate *Asphalt Concrete Gradation – 0.45 Power Curve* for the corresponding nominal maximum size aggregate. The 0.45 power curve uses a unique graphing technique to show the cumulative particle size distribution of an aggregate blend. The ordinate (vertical axis) of the chart is percent passing. The abscissa (horizontal axis) is an arithmetic scale of sieve size in mm of opening, raised to the 0.45 power. On these charts, the maximum density grading for a particular maximum size corresponds to a straight line drawn from the origin to the selected maximum aggregate size. It must be noted that this maximum density line is approximate, but can serve as a useful reference in proportioning aggregates. These power curves also depict other features.

Further, DOTD allows for all mixtures produced under Section 502 to be either on the coarse or the fine side A coarse and fine side gradation plot on the 0.45 power curve is shown in Figure 2-1

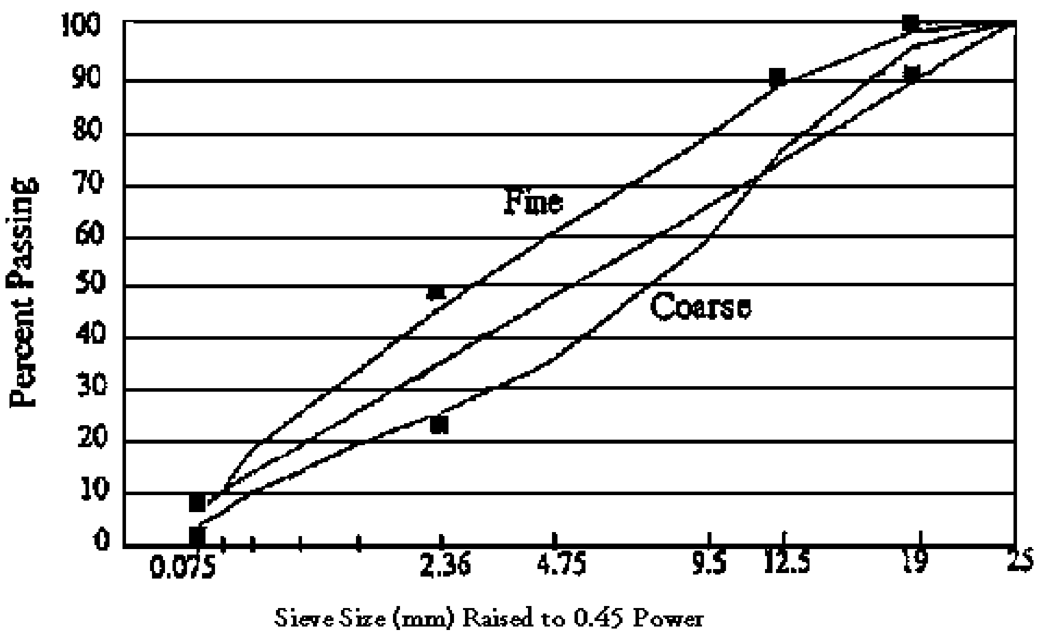



**Figure 2-1 – 0.45 Power Curve with Coarse and Fine Sided Gradations**

Care should be taken in the selection of the final composite aggregate blend. Many coarse graded blends may, if not properly designed and compacted, lead to pavements that are very porous and allow water to permeate the base and subbase.

Following is an example of the gradation requirements and a typical fine side proposed composite gradation 1/2 inch NMS:

**Example Gradation Tolerances and Limits**

| Sieve Size | Control Points | Mix Tolerance | Proposed JMF | JMF Limits |
|---|---|---|---|---|
| 1.0 inch | | ± 4 | 100 | 100 |
| ¾ inch | 100 | ± 4 | 100 | 100 |
| ½ inch | 90-100 | ± 4 | 99 | 95-100 |
| 3/8 inch | 89 max | ± 4 | 89 | 85-93 |
| No. 4 | | ± 4 | 57 | 53-61 |
| No. 8 | 29-58 | ± 3 | 34 | 31-37 |
| No. 16 | | ± 2 | 23 | 21-25 |
| No. 30 | | ± 2 | 17 | 15-19 |
| No. 50 | | ± 2 | 12 | 10-14 |
| No. 100 | | ± 2 | 7 | 5-9 |
| No. 200 | 4.0-10.0 | ± 0.7 | 5.1 | 4.4-5.8 |

For gradation purposes, all values are reported to the nearest whole number with the exception of the No. 200 sieve size, which is rounded to the nearest tenth.

Note that the mix tolerances are applied to the proposed JMF to determine the allowable upper and lower limit. Tolerance limits may only exceed control points during production, but not on the JMF nor during validation. For example, during validation, the JMF limits in the example above for the 3/8 inch sieve are 85 – 89.

(1) Blending Aggregates to Meet Friction Rating Requirements for Travel Lane Wearing Courses

Friction Rating – A friction rating is a relative indicator of the skid resistant properties of the aggregate. Friction ratings are assigned by the DOTD Materials and Testing Section to an aggregate source in accordance with Table 1003-3. These assigned friction ratings are listed for each aggregate in the Site Manager Materials system.

Aggregates used in Asphalt mixtures which are used for the **final lift of the mainline mix wearing course** have friction rating requirements in accordance with Table 502-3. The requirements are based upon current Average Daily Traffic (ADT) as shown on the plans and based on mix use and type. Generally frictional aggregates are not required in binder or base courses, shoulders, or in mixtures used for bike paths, curbs, driveways, guardrail widening, islands, joint repair, leveling, parking lots, patching, or widening. Table 502-3 is reprinted here from the Standard Specifications:

## Table 502-3
### Aggregate Friction Rating[1]

| Friction Rating | Allowable Usage |
|---|---|
| I | All Mixtures |
| II | All Mixtures |
| III | All mixtures except mainline wearing courses with plan ADT > 7000 |
| IV | All mixtures except mainline wearing courses[2] |

[1] Blending of Friction Rating III aggregates and Friction Rating I and/or II aggregates will be allowed for mainline wearing courses when plan current average daily traffic (ADT) greater than 7000. At least 50% by weight (mass) of the total aggregate shall have a Friction Rating of I or at least 75% by weight (mass) of the total aggregate shall have a Friction Rating of II.

[2] When the ADT is less than 2500, blending of Friction Rating IV aggregates with Friction Rating I and/or II aggregates will be allowed for mainline wearing courses at the following percentages. At least 50% by weight (mass) of the total aggregate in the mixture shall have a Friction Rating of I or II.

## Determination of RAP JMF Composite

**Given:**
15% RAP in mixture
0.8% AC from RAP
3.4% New AC to be added.

**Step 1: Calculate % AC in the reclaimed material.**
**Already completed in assumption**
To determine total AC content that will be attributable by RAP:
(% RAP/100)(% AC Residual from RAP)

**Step 2: Determine the percentage of RAP (by weight) in mixture.**
Subtract %AC in RAP from % RAP in mixture
15% - 0.8% = 14.2% Total RAP aggregate in mixture

**Steps 3 thru 5 is for determination of Total New aggregate .**
For this example new aggregates has been given as follows for VCF%
35.0% - SST #78
33.0% - LS #78
17.0% - LS #11
15.0% - Coarse Sand

100% Total New Aggregate

**Step 6: Calculate total material to be added to the new aggregate**
A) Add: % RAP Aggregate (14.2%)
% Reclaimed Asphalt (0.8%)
% New Asphalt Cement (3.4%)

14.2% + 0.8% + 3.4% = 18.4%

B) Subtract this percentage of material to be added to the new aggregate

100% - 18.4% = 81.6%

C) Convert to Decimal
81.6% = 0.816

D) Multiply this decimal times the bin proportions to determine Mix percentages. (% Total of new aggregate for each material) determined in Steps 3 thru 5.

| | |
|---|---|
| SST #78 | 35.0% x 0.816 = 28.6% |
| LS #78 | 33.0% x 0.816 = 26.9% |
| LS #11 | 17.0% x 0.816 = 13.9% |
| Coarse Sand | 15.0% x 0.816 = 12.2% |

**Step 7: Mix Percentages**

| | |
|---|---|
| **SST #78** | 28.6% |
| **LS #78** | 26.9% |
| **LS #11** | 13.9% |
| **Coarse Sand** | 12.2% |
| **RAP Aggregate** | 14.2% |
| **%AC from RAP** | 0.8% |
| **% New AC** | 3.4% |
| **TOTAL:** | **100.00%** |

**Step 8: Aggregate Percentages for Bulk Specific Gravity Computation**

A.) Total aggregate = 28.6 + 26.9 + 13.9 + 12.2 + 14.2 = 95.8

B.) New % of each aggregate by % of total aggregate = (for example) 28.6/.958 = 29.9

| | |
|---|---|
| **SST #78** | 29.9 |
| **LS #78** | 28.1 |
| **LS #11** | 14.5 |
| **Coarse Sand** | 12.7 |
| **RAP Aggregate** | 14.8 |
| **TOTAL:** | **100.00%** |

d) *Trial Blends with Varying Asphalt Cement Contents*

The contractor, following determination of the composite aggregate blend, shall prepare trial blends of asphalt mixtures with varying percentages of asphalt cement. These trial blends may be produced either in the design laboratory or the HMA plant.

The contractor shall prepare three trial blends with the proposed composite aggregate blend. One of the blends shall be prepared at an asphalt cement content near optimum (as defined by a specified air void content, $V_a$). A second trial blend shall be prepared at an asphalt cement content approximately 0.5% less than optimum. A third trial blend shall be prepared at an asphalt cement content approximately 0.5% greater than optimum. A minimum of two specimens @ $N_{des}$ shall be prepared at each of the trial asphalt cement contents.

The mixing and compaction temperature used for preparing the trial mixes shall be determined by the asphalt cement supplier and will be printed on the Certificate of Delivery that accompanies each transport of asphalt cement delivered to the plant. (The traditional method of determining asphalt cement mixing and compaction temperatures, via a temperature/viscosity chart is not valid for many of the polymer-modified asphalts now in use.)

Unless procedures require otherwise, the laboratory produced mix shall be cured 2 hours and plant produced mix shall be cured 1 hour at the compaction temperature (±10°F). When the aggregate water absorption is >2%, the oven aging time for plant-produced mix shall be 2 hours.

Once the trial blends have been prepared, specimens (briquettes) shall be tested for the following:

1. Bulk Specific Gravity, $G_{mb}$ at $N_{design}$
2. Air Voids, $V_a$ at $N_{design}$
3. Voids in Mineral Aggregate, VMA at $N_{design}$
4. Voids Filled with Asphalt, VFA at $N_{design}$
5. Percent $G_{mm}$ at $N_{initial}$
6. Percent $G_{mm}$ at $N_{design}$
7. Percent $G_{mm}$ at $N_{max}$

In addition, a loose mix sample from each trial blend asphalt cement content shall be prepared and tested for maximum theoretical specific gravity, $G_{mm}$ (Rice Gravity) using DOTD TR 327. For laboratory produced trial blends, the mixture, when tested for $G_{mm}$, shall be cured at compaction temperature for approximately two hours prior to specimen preparation. Plant produced trial blends require one hour curing or aging period. The $G_{mm}$ test values for the two specimens at each asphalt content shall be averaged to report a single value. For design purposes, the contractor may elect to prepare one loose mix near optimum AC content and calculate the high and low AC content $G_{mm}$. LaPave, the current DOTD design submittal spreadsheet uses this method. The verification blend will require two $G_{mm}$ tests averaged to report a single value.

After determing the optimum AC content and performing volumetric testing, the contractor will establish an AC Correction Factor for the proposed JMF according to TR 323. All JMF AC Correction Factors are subject to verification by the DLE.

Mineral aggregate is porous and can absorb water and asphalt to a variable degree. Furthermore, the ratio of water to asphalt absorption varies with each aggregate. The three methods of measuring aggregate specific gravity take these variations into consideration. The methods are bulk, apparent, and effective specific gravities. The differences among the specific gravities come from different definitions of aggregate volume. The department, for use when analyzing and documenting Superpave hot-mix asphalt mixtures, adopts the following definitions and nomenclature.

- Bulk Specific Gravity, $G_{sb,}$ the ratio of the weight in air of a unit volume of a permeable material (including both permeable and impermeable voids normal for the material) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 2-2

- Apparent Specific Gravity, $G_{sa}$ – The ratio of the weight in air of a unit volume on an impermeable material at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 2-2.

- Effective Specific Gravity, $G_{se}$ – The ratio of the weight in air of a unit volume of a permeable material (excluding voids permeable to asphalt) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 2-2.

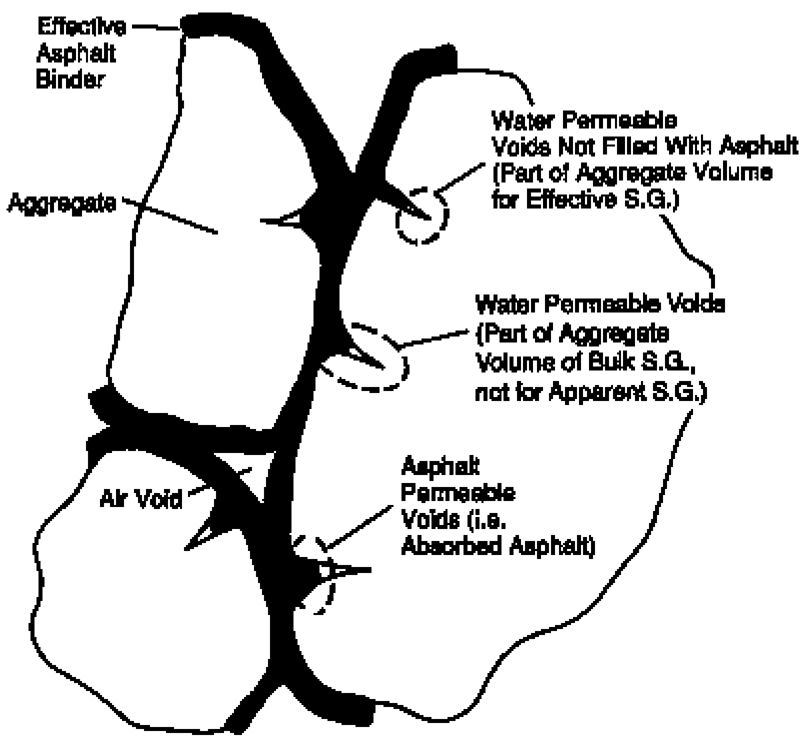



**Figure 2-2 – Illustrating Bulk, Effective and Apparent Specific Gravities, Air Voids, and Effective Asphalt Content in Compacted Asphalt Paving Mixture**

- Voids in Mineral Aggregate, VMA – The volume of intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective asphalt content, expressed as a percent of the total volume of the sample. See Figure 2-3.

- Air Voids, $V_a$ – The total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture. See Figure 2-3.

- Voids Filled with Asphalt, VFA – The portion of the volume of intergranular void space between the aggregate particles (VMA) that is occupied by the effective asphalt. See Figure 2-3.

- Effective Asphalt Content, $P_{be}$ – The total asphalt content of a paving mixture minus the portion of asphalt that is lost by absorption into the aggregate particles. See Figure 2-3.

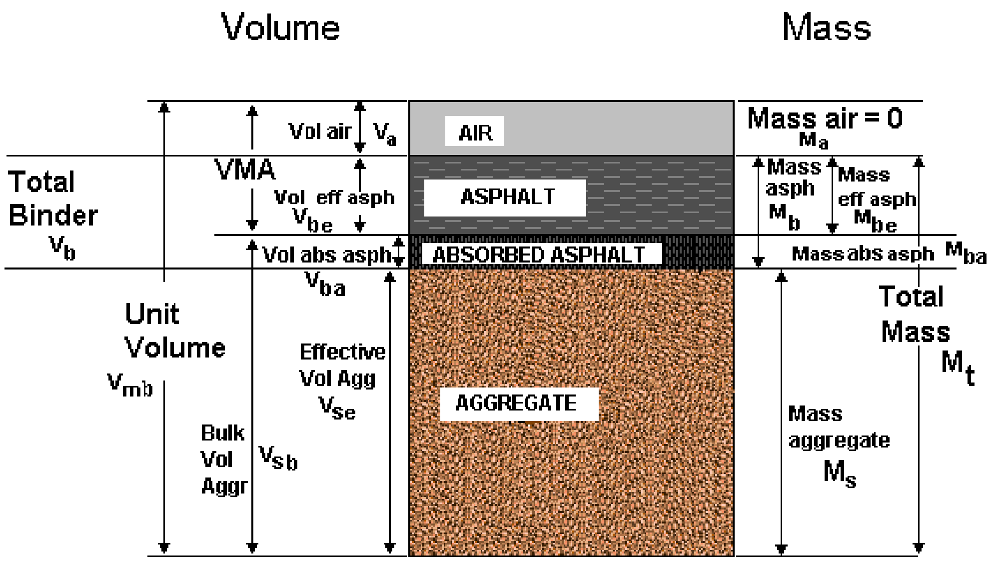



**Figure 2-3 – Representation of Volumes in a Compacted Asphalt Specimen (Phase Diagram)**

- Asphalt Cement Specific Gravity, $G_b$ – The ratio of the mass in air of a given volume of asphalt binder to the mass of an equal volume of water, both at the same temperature. **(Assumed to be 1.03)**

- Mixture Bulk Specific Gravity, $G_{mb}$ – The ratio of the mass in air of a given volume of compacted HMA to the mass of an equal volume of water, both at the same temperature.

- Theoretical Maximum Specific Gravity, $G_{mm}$ (Rice Gravity) – The ratio of the mass of a given volume of HMA with no air voids to the mass of an equal volume of water, both at the same temperature.

- Initial Number of Gyrations, $N_{initial}$) – This is the number of gyrations (7 gyrations) that represents a measure of mixture compactability. Mixtures that compact too quickly are believed to be tender during construction and may be unstable when subjected to traffic.

- Design Number of Gyrations, $N_{design}$ - This is the number of gyrations required to produce a density in the mix that is equivalent to the expected density in the field after traffic. In the mix design process, an asphalt content is selected that will provide 3.5% air voids when the mix is compacted to $N_{design}$ gyrations.

- Maximum Number of Gyrations, $N_{max}$ - This is the number of gyrations required to produce a density in the laboratory that would never be exceeded in the field. $N_{design}$ provides an estimate of the ultimate field density. $N_{max}$ provides a compacted density with some safety factor to ensure that the mixture does not densify too much, which would result in low in-place air voids, which can cause rutting. The air voids at $N_{max}$ are required to be at least 2%. Mixtures that have less than 2% air voids at $N_{max}$ are believed to be more susceptible to rutting than mixtures exceeding 2% air voids.

**The VMA values for compacted asphalt paving mixtures are to be calculated in terms of the bulk specific gravity ($G_{sb}$) of the combined aggregate.**

Voids in the mineral aggregate (VMA) and air voids ($V_a$) are expressed as percent by volume of the paving mixture. Voids filled with asphalt (VFA) is the percentage of VMA that is filled by the effective asphalt cement, ($P_{be}$). The effective asphalt cement content shall be expressed as a percent by weight of the total weight of the mixture.

The following equations are used to compute the volumetric properties of compacted hot-mix asphalt specimens:

**Bulk Specific Gravity of HMA Specimen $G_{mb}$**

$$G_{mb} = \frac{\text{Weight in Air}}{\text{SSD Weight} - \text{Weight in Water}}$$

**Air Voids, $V_a$:**

$$V_a = 100x\frac{G_{mm} - G_{mb}}{G_{mm}}$$

**Voids in Mineral Aggregate, VMA:**

$$VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}}$$

**Voids Filled with Asphalt, VFA:**

$$VFA = 100 \times \frac{VMA - V_a}{VMA}$$

**Effective Specific Gravity, $G_{se}$:**

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

**Percent Absorbed Asphalt, $P_{ba}$:**

$$P_{ba} = \frac{(100 \times G_b)(G_{se} - G_{sb})}{G_{sb} \times G_{se}}$$

**Percent Effective Asphalt Cement, $P_{be}$:**

$$P_{be} = P_b - \frac{P_{ba} \times P_s}{100}$$

**Dust to Asphalt Ratio, D/P or $P_{200}/P_{be}$:**

$$DustRatio = \frac{P_{200}}{P_{be}}$$

The asphalt mixture volumetric analysis results for the trial blends shall be documented in DOTD approved software.

The following relationships, as determined from these equations, shall also be plotted on an approved graph or the form to show the Optimum Asphalt Cement Content - Summary of Test Properties.

1. Air Void ($V_a$) versus asphalt content
2. Voids in Mineral Aggregate (VMA) versus asphalt content
3. Voids Filled with Asphalt (VFA) versus asphalt content

e) *Selection of Optimum Asphalt Cement Content*

Examining the test property curves reveals information about the sensitivity of the mixture to asphalt content. Trends generally noted are:

- The percent air voids ($V_a$) steadily decreases with increasing asphalt cement content, ultimately approaching a minimum void content.

- The percent voids in the mineral aggregate (VMA) generally decreases to a minimum value then increases with increasing asphalt cement content.

- The percent voids filled with asphalt (VFA) steadily increase with increasing asphalt cement content because VMA is being filled with asphalt cement.

The design asphalt cement content of the mixture is selected at that percentage yielding the median percentage of the range of air voids (which is 3.5% for all asphalt mixtures) and yielding the required design target for VFA (which is 72% minimum). In addition, all of the calculated and measured mix properties at this asphalt cement content should then be evaluated and compared to the specified values in Table 502-6. If all of the design criteria are not met, then some adjustment is necessary or the mix may need to be redesigned.

f) *Dust to Effective Asphalt Cement Ratio Evaluation*

Another mixture requirement, as per Table 502-6, is the dust ratio. This is computed as the ratio of the percentage by weight of aggregate finer than the No. 200 sieve to the effective asphalt content ($P_{be}$) expressed as a percent by weight of the total mixture. Effective asphalt content is the total asphalt used in the mixture less the percentage of absorbed asphalt.

**Dust to Asphalt Ratio, D/P or $P_{200}/P_{be}$:**

$$\text{Dust Ratio} = \frac{P_{200}}{P_{be}}$$

The dust ratio, $P_{200}/P_{be}$, tolerance for all asphalt mixtures is 0.6 to 1.6 unless otherwise stated.

g) *Moisture Sensitivity Analysis*

Subsection 502.02.2.1 requires that a minimum of 0.6% anti-strip be used.

h) *Loaded Wheel Tester, LWT Testing*

Perform: (AASHTO T 312) Preparing and Determining the Density of Asphalt Specimens by Means of the Superpave Gyratory Compactor and (AASHTO T 324) Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (LWT) tests. Specimens shall be prepared and tested according to T 312 and T 324. Testing tolerances are listed in Table 502-6 of the Standard Specifications.

Report values will be included in the JMF submittal. Raw data will be provided to the department upon request.

*Semi Circular Bend Test (SCB)*

Perform according to TR 330. The contractor will perform SCB testing for design. The SCB test for design submittal may be witnessed by a DOTD employee at the request of the DLE. The contractor will coordinate with the DLE for an employee to be present for testing.
The contractor will submit required data with the JMF proposal.

i) *Tensile Strength Ratio, (TSR), (Lottman) (Minor Mixes)(Optional)*

To complete the design process for minor mixes, the contractor may, in lieu of LWT, perform the moisture sensitivity test (DOTD TR 322) to evaluate the proposed hot-mix asphalt blend for stripping. This test identifies whether a combination of asphalt binder and aggregate is moisture susceptible.

Results will be reported on the TSR Form (in LaPave) and forwarded to the district laboratory engineer with the JMF proposal. When the results are less than 80%, no further production for that job mix formula or any proposed job mix formula substituted for that mix type will be accepted on any DOTD project having DOTD TR 322 requirements until a passing plant-produced Tensile Strength Ratio (TSR) value is verified by the Department.

j) *SMA Design Criteria*

SMA is hot-mix asphalt consisting of two parts: a coarse aggregate skeleton and binder rich mastic. SMA mix design is to have a gap graded stone-on-stone coarse graded skeleton. SMA shall have a minimum 6.0% PG 76-22m or PG 82-22rm AC in design and production. VMA shall be a minimum of 16.0% in design and production. Mineral fillers and/or fibers may be used to help to minimize draindown. Draindown shall not exceed 0.3% in design or production. Design criteria shall meet specifications in Table 502-6 of the Standard Specifications. RAP is not allowed in SMA.

SMA shall be designed according to the Superpave method utilizing these five design steps:

- Select proper aggregate materials
- Determine an aggregate gradation yielding stone-on-stone contact.
- Ensure the chosen gradation meets or exceeds minimum VMA requirements.
- Choose an asphalt content that provides the desired air void level
- Evaluate the moisture susceptibility and asphalt cement draindown.

SMA Job Mix Formulas shall be submitted a minimum 10 days prior to production along with a laboratory specimen at optimum design cut in half for stone-on-stone contact evaluation by the DLE.

High AC content mixes such as SMA may need an adjustment factor for calculating yield and pay.

k) *Submittal Process and Documentation – (JMF Submittal Form)*

Once the optimum asphalt cement content has been determined for the proposed aggregate blend and the consensus aggregate tests, dust proportion, LWT (Optional Lottman for Minor Mix) and SCB analysis have been completed, the certified contractor is prepared to submit the proposed job mix formula (JMF) to the district laboratory engineer. The JMF shall be submitted on a properly completed JMF Asphalt Mixture Form that is part of the DOTD approved software program.

The Contractor shall submit the JMF using the Department's approved software program. The JMF shall indicate the optimum mixing temperature and range as suggested by the asphalt binder supplier. In addition, the following information shall also be submitted to the district laboratory engineer with the JMF.

1. A proposed blend summary with individual source and composite gradations, volumetric analysis at optimum asphalt cement content, including two $N_{design}$ and one $N_{max}$ briquette.
2. Bulk specific gravity, $G_{sb}$, of each aggregate and the combined bulk specific gravity for the mineral aggregate blend. Friction ratings if applicable. Bulk specific gravity ($G_{sb}$) of RAP aggregate and % AC of RAP.
3. A graph on the Asphalt Concrete Gradation – 0.45 Power Curve form, showing proposed composite gradation plotted to the 0.45 power curve
4. A quantitative summary of three (minimum) trial blends at optimum and ± 0.5% asphalt cement along with volumetric calculations. A minimum of two $N_{design}$ gyratory specimens for each blend point.
5. A verification blend at Optimum Asphalt Cement Content - Summary of Test Properties showing VMA, $V_a$, VFA, versus asphalt cement content.
6. Coarse aggregate angularity (CAA) test results and calculations.
7. Fine aggregate angularity (FAA) test results and calculations.
8. Flat and Elongated Count (FE) test results and calculations.
9. Sand equivalency (SE) test results and calculations.
10. LWT Testing Data.
11. SCB Testing Data.
12. Water Susceptibility (Lottman Test) results (Minor Mixes).
13. Draindown test for SMA mixes.

Verification point of the proposed JMF will include: Gyratory compactor test results for at least two samples (laboratory or plant produced) prepared at optimum asphalt cement content for the proposed trial blend compacted to $N_{design}$ and one sample compacted to $N_{max}$. Two loose mix sample tested for $G_{mm}$ at optimum asphalt cement and averaged for a single value.

The original signed JMF Proposal, along with the supporting documents, shall be submitted together to the district laboratory engineer for approval no less than 7 days before anticipated production is to begin.

l) *Approval of JMF Proposal*

Prior to approval of a submitted JMF, the submitted JMF documents must be checked for completeness and accuracy. The following are guidelines for checking a submitted JMF:

- District laboratory verified values for aggregate stockpile $G_{sb}$ and consensus testing determined during the initial design phase are compared with submitted values to ensure they meet the criteria indicted within the design section of this manual.

- Design specification criteria:
  - $G_{mm}$
  - $G_{mb}$
  - $V_a$
  - VMA
  - VFA (Design at 72%)
  - LWT (Rut Testing) Data
  - SCB (Semi Circular Bend) test results
  - Water Susceptibility (Modified Lottman) (Minor Mixes)
  - Draindown for SMA

Upon approval of the proposed JMF, the DLE will give it a numerical identification (the JMF Sequence Number). This identifying code must be clearly written, typed, or printed on the JMF Proposal From and all supporting documentation.

**NOTE:**

**The DLE or their representative must approve the proposed Job Mix Formula before any mixture can be produced for the department.**

Upon approval of the JMF, the DLE will electronically approve or sign in the Proposal Approved section of the document and date it. The district laboratory will send an approved JMF to the contractor and P.E. office.

### 3. <u>Validation of JMF Proposal</u>

Once the DLE has approved the JMF for validation, the plant may begin producing mixtures for the department in accordance with the JMF. However, before the validation process begins for the approved JMF Proposal, the project engineer in charge of the project must verify that the mix type and project specifications for the project(s) receiving the mix are the same as the proposed mix design and appropriate for the application.

The first day's production or a maximum of 2000 tons of mix shall be used to validate a new JMF. The contractor and the Department using the stratified random sampling approach, shall jointly take and test five samples, one per validation sublot, during the validation lot. Validation of a JMF requires a minimum of 1000 tons. Multiple day validation is acceptable.

The contractor, with the approval of the Department, may exclude any one irregular validation sublot test set representing any one validation sublot tested from the validation analysis provided the validation is adjusted to meet the minimum number of samples.

Specifications state that payment for validation is considered part of the first roadway lot of production and will be in accordance with acceptance pay parameters, based on cores.

It is the responsibility of the contractor to always provide the project engineer with a copy of the approved JMF proposal and anticipated validation schedule prior to production for a particular project. The contractor shall coordinate with the DLE and ADI for DOTD staffing of validation testing.

The JMF proposal validation will be completed on the first production lot in accordance with Subsection 502.04. The evaluation is designed to ensure that the mixture produced in the plant meets the tolerances set forth in the JMF proposal and to establish the approved Job Mix Formula. Ensure that the minimum lift thickness is maintained based on the nominal maximum size of the aggregate per Table 502-6.

The performance of the mixture on the roadway will also be evaluated to ensure that the JMF is not contributing to laydown deficiencies, such as segregation, tenderness, workability, compactability, or surface texture problems. Mixtures that are identified as causing any laydown deficiency will not be validated. The project engineer in charge of the project or the DLE may deem a proposed JMF invalid for roadway deficiencies. If deficiencies are discovered, the roadway inspector will inform the plant inspector, the project engineer, and the DLE.

Additionally, if the mixture exhibits uncoated aggregate or possible moisture problems, the Contractor and department inspector will perform DOTD TR 328 (Ross Count) to ensure that the mixture meets the 95% coating requirement of the specifications (Subsection 503.06) and DOTD TR 319 to ensure that the moisture content of the mixture does not exceed the 0.3% specification requirement.

a) *LWT (Rut Testing) Validation of JMF Proposal*

The Department inspector shall prepare 4 gyratory specimens 60mm in height at 7 ±1% air voids in accordance with AASHTO T312 (larger specimen can be fabricated and cut to height). The estimated weight required for the specimen will depend upon the $G_{mm}$ of the mixture. The specimen shall be delivered to the District Lab for LWT testing in accordance with AASHTO T324. Additional loose mixture sufficient for retesting shall be obtained and transported to the District Lab in the event that the original specimens do not meet the air void requirement. When the LWT rut depth results exceed the requirements in Table 502-6, discontinue production and reevaluate the JMF. If it is determined the contractor is not able to adjust the mix within allowable bin tolerances (±4% for validation), disapprove the JMF. A previously validated and approved JMF may be used in lieu of the disapproved JMF.

b) *Failure to Validate Procedure*

If a mixture design fails to validate, a second validation attempt will be allowed. If a validation fails, a new proposal must be submitted and validation testing repeated or the producer may use a previously approved Job Mix Formula. No mixture shall be produced for a DOTD project until the DLE has approved a new JMF proposal. If the JMF does not validate, the DLE will indicate disapproved on the proposed JMF Proposal, enter the sequence number, date and sign it (Disapproved). Copies of the disapproved JMF Proposal will be distributed to each project engineer who received a portion of the lot.

Repeated validation failures indicate a serious problem with quality or quality control. If the first and second validation attempt fails any quality characteristic or roadway pay is less than 100% on both attempts, redesign and try another validation off site. The contractor will not be allowed to place the mixture on any DOTD project. The contractor must redesign and validate off-site, not on state property and at no direct pay. The off-site validation plan must be pre-approved by the DLE. Once completed, the validation data is promptly forwarded to the district laboratory engineer for review. The DLE will determine if an additional validation is required on the state project. If the contractor must validate off-site, they may coordinate with the DLE to request the Asphalt District Inspector be present for the off-site validation attempt in order to avoid a second validation.

**NOTE:**

Validation Lots shall comply with 502.05 Quality Control and Plant Acceptance “cease operation if two consecutive Mainline Lots fail to meet 100% pay and re-validate off site prior to continuing”.

### 4. Final Approval of JMF

Upon validation of the JMF, the validation averages will be used for JMF production target values. Mixes that do not require validation such as minor mixes, the first five P-Lot test results from a specific JMF will be used to establish further production target values.

The DLE, upon receipt of the validated JMF and supporting PWL (Percent Within Limits) calculations, will approve the validated JMF for production. Once a completed mixture design has been validated and approved, the same JMF may be used for all projects having the same specification requirements.

It is the responsibility of the Contractor to provide the project engineer (in charge of a project anticipating receiving mix from the plant) with a copy of the approved Job Mix Formula (cover sheet only) prior to production (a facsimile will suffice). The Project Engineer will send a copy to the roadway inspector.

The DLE will provide the contractor, producer, department plant personnel, and the project engineer who is receiving the mixture with an approved copy of the mixture design for project records.

In summary:

1. Contractor submits proposed JMF to District Lab Engineer (DLE)
2. DLE approves JMF for Validation

3. Validation is performed, data analyzed
4. DLE (or designee) reviews and approves.
5. Validated proposal becomes new Approved JMF.

All JMF’s shall be re-validated a minimum of every 2 years. Re-validation may consist of reviewing ongoing production plant data and plant verification data.

A summary of the Asphalt concrete mix design steps is shown on the following two pages.

# PART 2 – DESIGN, PRODUCTION, AND ACCEPTANCE

# Asphalt Concrete Mix Design Steps

## Material Procurement

### Coarse Aggregate
- Approved Materials List?
- Friction Rating OK?
- $G_{sb}$ Determined?
- Gradation Determined?
- CAA Determined?
- Flat & Elongated Determined?

### RAP
- Approved Stockpile?
- Gradation Determined?
- Percent AC Determined?
- $G_{sb}$ Determined?

### Fine Aggregate
- Approved Materials List?
- $G_{sb}$ Determined?
- Gradation Determined?
- FAA Determined?
- SE Determined?

### Asphalt Cement
- Approved Materials List?
- Correct Grade?

## Blending Aggregates

- Mixture Type Determined From Project Plans?
- Nominal Maximum Aggregate Size Determined?
- Aggregate Mathematically Blended to Meet Table 502-4?
- Composite Gradation Plotted on the 0.45 Power Curve?
- Blended Gradation Within Control Points?
- Blended Gradation Within FAA Specification?
- Blended Gradation Within CAA Specification?
- Blended Gradation Within SE Specification?

## Preparing Trial Blends Using Varying Asphalt Contents

- One Trial Blend Prepared At Optimum AC%?
- One Trial Blend Prepared 0.5% Above Optimum AC%?
- One Trial Blend Prepared 0.5% Below Optimum AC%?
- Two Specimens Prepared at Each Trial Blend?
- Loose Mix Specimens Prepared at Each Trial Blend?

# Asphalt Concrete Mix Design Steps

## Testing and Evaluating Trial Blends Using Varying Asphalt Contents

- $G_{mm}$ Determined?
- $G_{mb}$ @ $N_{design}$ Determined for Each Blend?
- $V_a$ @ $N_{design}$ Determined for Each Blend?
- VMA @ $N_{design}$ Determined for Each Blend?
- VFA @ $N_{design}$ Determined for Each Blend?
- Percent $G_{mm}$ @ $N_{initial}$ Determined for Each Blend?
- Percent $G_{mm}$ @ $N_{design}$ Determined for Each Blend?
- Percent $G_{mm}$ @ $N_{max}$ Determined for Verification Blend?

$V_a$ "vs" Asphalt Content Plotted on Graph?

VMA "vs" Asphalt Content Plotted on Graph?

VFA "vs" Asphalt Content Plotted on Graph?

## Selection of Optimum Asphalt Cement Content

- Optimum Blend Yeilding Design $V_a$ Determined?
- Blend Prepared at Optimum Asphalt Content?
- VMA @ Design Blend Within Specifications?
- VFA @ Design Blend Within Specifications?
- $N_{initial}$ @ Design Blend Within Specifications?
- $N_{design}$ @ Design Blend Within Specifications?
- $N_{max}$ @ Design Blend Withing Specifications?
- Dust / Effective Asphalt Ratio Within Specifications?
- Semi-Circular Bend Test (SCB) Within Specification?
- Loaded Wheel Test (LWT) Within Specification?

**SMA** requirements:
Select proper aggregate gradation

Aggregate gradation yielding stone on stone contact

Ensure gradation meets minimum VMA Requirements

Asphalt content provides desired void content

The mix meets moisture susceptibility and asphalt

## Job Mix Formula, JMF Submittal

### Asphaltic Concrete Job Mix Release Form

- Proposed Blend Summary
- $G_{sb}$ of Each Aggregate and Combined $G_{sb}$
- 0.45 Power Curve With Control Points
- Summary of Three Trial Blends
- Optimum Asphalt Cement Content Summary of Test Properties (Verification)
- Coarse Aggregate Angularity, CAA Test Results
- Fine Aggregate Angularity, FAA Test Results
- Flat and Elongated Count, FE Test Results
- Sand Equivilancy, SE Test Results
- Gyratory Compactor Test Results For Two Samples Prepared At Optimum AC
- Loaded Wheel Test (LWT) or when allowed Tensile Strength Ratio, TSR Test Results
- Signed Copies of JMF Forms

## B. Definition of a Lot

### 1. Plant Lot (P-Lot)

For quality control purposes, obtain a mixture sample from each 1000 tons of plant-produced mixture ("plant lot", or "P-lot") using a stratified random sampling approach. A representative sample shall be sufficient to provide enough mixture for all quality control testing.

Definition of a P-lot: A plant lot is a segment of continuous production of Asphalt concrete mixture from the same job mix formula produced for the Department at an individual plant. The P-lot will be used for quality assurance purposes without pay adjustments. The P-lot is independent of project delivery locations. P-lot designation shall be reported on each haul ticket delivered to each state project.

The contractor shall maintain in the plant lab a "Field Book" tracking the production of P-Lots. Minimum information to be maintained:

- Date
- State Project(s) mix shipped to
- DOTD JMF sequence number and P-Lot No. (ex. 101-001)
- Tons shipped
- Accumulated tons of JMF
- Remarks
- Initials (if written logs are maintained)
- AC Type

P-Lots will be designated with DOTD JMF sequence number followed by the sequential lot number of a particular JMF.

Example: 101 (JMF Sequence #)-002 (second P-lot of JMF) – B (second test of P-lot)
101-002-B, 101-003, 101-003-B, 101-003-C, 101-004, etc.

The P-Lot sequential numbering for a specific JMF continues and does not start over from project to project. This is intended to track the history of a JMF through multiple projects for the life of the JMF.

A JMF that is originally submitted as a level 1 wearing coarse could also meet specifications for a Level A. If a district wishes to track the performance of the aggregate structure to compare to the original submittal, a modified sequence number could be used. Ex. JMF # 101 for the original W.C. submittal and JMF # 101(67) for submittal as a Level A. The (67) denotes the that the original JMF contains PG67-22.

It may take multiple days to complete a P-Lot in which case the contractor shall perform and report multiple Quality Control test on an individual P-Lot. When production is equal to or greater than 100 tons per day per JMF, Quality Control testing shall be performed and reported into the DOTD tracking software.

A standard P-lot is 1000 tons, minor adjustments will be made in the 1000-ton P-lot size to accommodate hauling unit capacity. When the total P-lot quantity is expended in the partial load of a truck, the full legal load of the truck will be included in the P-lot. For example, if 988 tons of HMA are produced and sent to a project and the next truck hauls 24 tons, the actual P-lot size will be 1012 tons (988 + 24).

### 2. Roadway Lot

A lot shall be either mainline asphalt mix or minor asphalt mix as defined in 502.01.2. Keep mainline and minor asphalt lots separate.

When shoulder mix ≤4 feet in width is paved with the mainline mixture it will be considered a minor lot without density requirements compacted to the satisfaction of the engineer. When paved with the mainline, the shoulder tonnage will be based on theoretical quantity.

Minor Mix requirements will be based on sections:

502.10.2.2 Minor Lots with Density Requirement
502.10.2.3 Minor Lots without Density Requirement
502.11.1.3 Testing for Minor Mix with Density Requirements
502.11.1.4 Testing for Minor Mix without Density
502.15.3 Payment for Minor Mixes

Minor Mix Roadway lots are project specific. Each lot is unique for a project.

> Example: Patching (minor mix) is JMF 101. Start with Roadway Lot 01 in project tracked 1000 ton minor mix lots
> Mainline Wearing Course is JMF 102. Roadway Lot 02 tracked in 37,500' lots with 7500' sublots.
> Minor Shoulder Mix is JMF 103. Roadway Lot 03 in project tracked 1000 ton minor mix lots.

The tonnage and P-Lots will be tracked within Roadway Lots and referenced by station to station.

The wearing course is defined as the final lift placed. The binder course is defined as the lift placed prior to the final lift. 501 mixtures placed over 502 are defined as Finish Courses.
Mainline mixtures include wearing, binder and base courses for travel lane, ramps greater than 300', interstate acceleration/deceleration lanes, center turn lanes, and the two center lanes for airports.

Minor mixes include mixture used for bike paths, crossovers, curbs, detour roads, driveways, guardrail widening, islands, joint repair, leveling, medians, parking lots, shoulders, turnouts, ramps less than or equal to 300', patching, widening, miscellaneous handwork, and any other mixture that is not mainline.

#### a) *Mainline Mix Lot Sizes*

For mainline mixes, a typical roadway lot is 37,500 linear lane feet of plant produced mixture from a specific JMF placed consecutively on the roadway. Any project with less than 37,500 linear lane feet (11,250 linear lane m) is also defined as a lot. A sublot is defined as 7500 linear lane feet.

Payment will be made based on tons received on the job. Linear lane feet that make up the lot includes only the paved width regardless of the lane width shown on the plans.

Acceptance sample locations will be identified by the DOTD inspector at a rate of one random location every 2500 feet of the travel lane. The contractor will cut cores in the presence of DOTD inspector. Refer to the appendix for applying random numbers Results shall be reported within the DOTD approved software system on the same day as tested.

Verification and resolution core locations will be identified by the DOTD inspector at a rate of one random location every 7500 feet. The contractor will cut the cores in the presence of the DOTD inspector. The DOTD inspector and contractor will take custody of the appropriate cores for delivery to the district lab and asphalt plant lab.

All cores shall be properly identified by the corresponding roadway lot, project number, date cored, and station number. The Certified Roadway Inspector shall list the generated random numbers on the Roadway Report.

b) *Minor Mixes*

Lot size for minor mixes will be defined on the project by 1000 ton, in place, lots by mix type. Minor Mix with density requirements will be tested at the rate of three (3) cores per 1000 tons based on Tables 502-5, Asphalt Pavement Requirements and 502-7 Payment Adjustment Schedule for Minor Mix Asphalt. Inspectors will track minor mixes by JMF in 1000 ton "Roadway Lots".

Minor mix use for patching and widening with density requirements may use 4 inch cores. Patching and widening cores will have the bottom base material trimmed to "clean up" the core. The whole core will be tested for density.

For projects, or separate locations within a project, requiring less than 250 tons, the job mix formula, materials, and plant and paving operations shall be satisfactory to the engineer. Sampling and testing requirements may be modified by the engineer and the payment adjustment for deviations waived.

Verification of Minor Mixtures: For minor mixes that do not require density, a negative pay adjustment of 5 percent will be applied when plant mix is out of specifications on plant voids. For minor mixes without density requirements, the Project Engineer will select three locations for the contractor to core and will send the roadway cores to the District Lab for $G_{mm}$ verification. The average $G_{mm}$ measured at DL shall be within 0.024 of the JMF. When $G_{mm}$ from random roadway cores do not verify with the established plant $G_{mm}$ , the DLE may terminate the JMF or re-establish plant $G_{mm}$.

## C. Quality Control

### 1. Plant Quality Control

The contractor shall provide a Level II or III Certified Asphalt Concrete Plant Technician at the plant for start of daily mixture production capable of conducting any test or analysis necessary to put the plant into operation and producing a mixture meeting specifications. After the arrival of the Certified Asphalt Concrete Plant Technician, begin daily plant operations. Provide proof of Asphalt Concrete Plant Technician certification awarded by the Department upon request. A Level I or above Certified Asphalt Concrete Plant Technician may test mix for conformance with specifications. A Level III Asphalt Concrete Plant Certification shall be required to design Asphalt Concrete Mixtures and submit JMFs for approval to DOTD.

# PART 2 – DESIGN, PRODUCTION, AND ACCEPTANCE

The primary responsibility of the contractor is to design asphalt mixtures, and control the production to ensure that it consistently meets departmental requirements.

The contractor’s certified technician shall be at the plant for the beginning of daily operations. Whenever HMA mixtures are being produced for a DOTD project, the contractor’s certified technician must be either at the plant or the paving site.

It is the contractor’s responsibility to ensure that all tasks necessary to begin plant operations are performed. This includes, but is not limited to, checking asphalt cement working tanks, material stockpiles, aggregate bins, cold feed settings, meters and scales. The certified technician is responsible for recommending appropriate adjustments and ensuring that these adjustments have been made during continuing operations to ensure uniformity and conformance to specifications.

In addition, the contractor’s certified technician shall oversee and monitor the complete production, transport, placement, and compaction phases to ensure compliance with DOTD specifications and to promote consistency.

The Contractor’s certified technician shall be knowledgeable of proper plant operations and be aware of moisture inconsistencies. When the plant is put into operation, the Contractor shall monitor stockpiles to ensure that they are constructed properly and that moisture contents entered into the plant controls are consistent with actual values for each material bin.

Plant operations are to be continuously inspected to ensure the following:

- Proper bag house operation (startup and shutdown loads will not be impacted by improper sequence of fines returned from the dust collection system, producing material with inconsistent amounts passing the No. 200 sieve.)

- Sufficient HMA is wasted at startup and shutdown to ensure adequate, sufficient, and consistent asphalt cement rates.

- Proper loading of trucks to minimize material segregation.

a) *Minimum Quality Control Testing*

***Loose Mix / P-Lot**
Theoretical Maximum Specific Gravity, $G_{mm}$
% Asphalt Content
Gradation
% Crushed
Temperature of Mix
Mix moisture

***Compacted Specimen, / P-Lot**
LWT (Every 20,000 Tons)
% $G_{mm}$ @ $N_{initial}$
%$G_{mm}$ @ $N_{design}$

% Air Voids, $V_a$
% VMA
% VFA
%$G_{mm}$ @ $N_{max}$ 1 per 5 P-Lots for information only

Age all loose mix prior to testing for one hour in a shallow pan in accordance with AASHTO R30. This includes Theoretical Maximum Specific Gravity, ($G_{mm}$), LWT and mixture for gyratory briquettes.

*The contractor will test for Quality Control when 100 tons or more are shipped per JMF per day. The test results will be entered into DOTD's approved tracking software. This will be noted as B, C, D….etc of a designated P-Lot.

For WMA mixtures, age samples for 2 hours.

(1) LWT Testing

Obtain a sufficient sample for LWT testing in accordance with DOTD S201 for every 20,000 tons of plant produced mixture.

(2) Gradation

Sampling and testing shall be in accordance with Materials Sampling Manual. Proper sampling is crucial for accurate results that represent actual plant production.

The contractor should also, at regular intervals, check to ensure that the aggregate proportioning system, as well as the RAP proportioning system, is in calibration. This may be a two-step process. First, the weighbridge is checked to ensure that it is in calibration. This may be determined by running a known mass of material over it and correcting the weighbridge factor to get it into calibration over the full span of expected weights. Secondly, each cold feed bin should be calibrated as needed to ensure that the proper mass of material/per unit time is being proportioned from the individual bin.

**NOTE:**

In any method used, the measured weight of the aggregate includes moisture in the aggregate.

Should the extracted gradation begin to vary erratically, the aggregate and RAP proportion systems should be immediately checked along with individual stockpile gradations and moisture contents.

(3) Asphalt Cement Content and Properties

The asphalt cement content may be determined in two ways. 1. The ignition oven (DOTD TR 323) with the pre-determined ***correction factor***. 2. Asphalt meter: the rate of asphalt cement delivery is continuously shown, in digital form, on all modern plant controls. If the delivery rate of asphalt cement plus the asphalt credit from RAP (if used) differ by more than ±0.3% from the Ignition Oven (with correction factor) for two (2) out of five (5) on the rolling average, take corrective action. Corrective action can be reestablishing the correction factor, recalibrating the asphalt cement metering system or other systems of the plant. Document and forward to the DLE the cause and corrective action taken.

**NOTE:**

Note that excess moisture in the mix may falsely appear as asphalt cement during the Ignition Oven test procedure; it may also artificially increase or decrease the $G_{mm}$. Higher or lower asphalt content will also reduce or raise $G_{mm}$.

The Contractor should ensure that the Asphalt cement strainers and screens are clear and operational.

Asphalt cement shall be sampled, tested and accepted in accordance with Sections 502 of the *Materials Sampling Manual.*

The Approved Materials List Asphalt Cement supplier shall:

- Sample and test the product
- Provide a Certificate of Analysis to the Materials Laboratory (electronic media is acceptable)
- Provide a Certificate of Delivery with every transport representing the material shipped to the HMA facility

The transport will arrive at the plant with a Certificate of Delivery (CD). The contractors certified inspector shall collect the CD and provide copies to the DOTD inspector upon request. This Certificate of Delivery constitutes acceptance for asphalt cement for the project. A representative of DOTD will sample working tanks a minimum of once per month during random visits and transports as requested by the Materials Laboratory. The samples will be delivered to the district lab for proper handling.

For Verification of Asphalt Cement, CD's shall be clearly identified with the following:

- Plant Code, e.g.
- Asphalt Cement Grade
- Certificate of Delivery and Analysis Number
- Sample ID Number
- Date Sampled
- Quantity

(4) Laboratory Volumetrics

The Contractor shall conduct quality control tests to ensure that volumetrics are within specification range. Sampling and testing shall be in accordance with the Materials Sampling Manual.

(5) Additives

The Contractor shall check the rate of anti-strip at the beginning of each operational period, and when necessary thereafter, to ensure that the mixture is receiving the percent of anti-strip required by the JMF.

If other additives are used, the Contractor shall also check the rate at the beginning of each operational period, and when necessary thereafter, to ensure that the mixture is **receiving the percent of additive required by the JMF.**

(6) Temperature

**The temperature of the asphalt cement and of HMA is very critical. It is also critical that the temperature of these two products be as specified and be consistent.**

Specific attention shall be given to monitoring temperature in all asphalt cement working tanks and to ensure that all materials added, particularly from transports, are also at the correct elevated temperatures. Temperature is directly correlated with viscosity, which will affect the material's ability to adequately coat the aggregate.

Specifications require that a thermometer be provided to indicate mixture discharge temperature (typically at the discharge of the drum mixer). Mixture temperature consistency is essential in obtaining consistent roadway compaction. The technician may check this thermocouple temperature against either an infrared gun-type thermometer device or by using a standard, calibrated dial thermometer.

The JMF stipulates an optimum mixing temperature range of ±25° F of the optimum mixing temperature for the asphalt cement used. The discharge temperature shall always be within this range. **Mixing temperature must never exceed 350°F at the point of discharge, regardless of the supplier's recommendations.** Further, Subsection 502.08 of the *Standard Specifications* states that no mixtures shall be delivered to the paver cooler than 25° F below the lower limit of the compaction temperature as allowed by the JMF. **The temperature of the mix going through the paver shall not be cooler than 245° F.**

(7) Moisture

Stripping of asphalt mixtures is less likely to occur in the absence of moisture or moisture vapor. To approach this ideal state, all hot-mix asphalt materials should be produced in a manner that minimizes internal moisture, because internal aggregate moisture can weaken the molecular bond between the asphalt cement and the mineral aggregate.

However, with the average annual rainfall and humidity present in Louisiana, it is difficult to remove all free and absorbed moisture from aggregate in the HMA production process. In a typical plant, when fuel is burned, a quantity of heat is produced. This heat is transferred to the aggregate to evaporate moisture and heat the aggregate. As moisture in the aggregate is evaporated, each pound of water expands to 33 cubic feet of steam. This enormous volume of steam must be removed by the plant's exhaust system. Hence, when aggregate moisture values increase (as in the presence of recent rainfall), the plant's production rate and burner settings must be adjusted to maintain and achieve consistent mixture temperatures and remove sufficient moisture. Excessively worn or missing flights will greatly affect the plant's ability to heat and dry aggregates. The drum mixer shall also be routinely inspected for excessive flight wear.

The presence of moisture also aggravates the process of accurately measuring mixture volumetrics. Excessive moisture in hot-mix asphalt may lead to an abrupt collapse in Voids in Mineral Aggregate.

The contractors certified technician shall monitor and record the moisture in the individual aggregate stockpiles for Quality Control purposes. The stockpile moisture records shall be maintained at the asphalt plant and made available to the DLE and ADI.

Moisture content (M.C.) for each aggregate is calculated by the following equation:

$$\text{M.C.\%} = \frac{(\text{Wet Weight} - \text{Dry Weight})}{\text{Dry Weight}} \times 100$$

Therefore, to determine the *dry* mass, knowing moisture content, the following equation may be used:

$$\text{Total Dry Weight} = \frac{\text{Total Wet Weight} \times 100}{100 + \text{M.C.\%}}$$

Report the percent moisture which is not to exceed 0.3 percent by weight (mass) in loose mix as part of QC testing of plant produced mixture tested in accordance with DOTD TR 319. Mix moisture shall be tested and entered into the DOTD approved tracking software for each QC production sample set.

The Contractor is to document all QC testing and keep these records on file at the plant laboratory as electronic or hard copies as well as entering into the DOTD approved tracking software.

## D. Plant Inspection

*When QC/QA inspection or tests indicate that the contractor's QC/QA program is not effective, the Asphalt District Inspector or DLE will require modifications to the program. DOTD has the right to require changes in personnel, equipment, construction methods, testing methods or frequency. The contractor will not be allowed to proceed with construction operations without an effective QC/QA program which complies with specifications.*

*A key element of inspection is the review of the contractor's QC/QA results and program. Evaluations of the QC effort to ensure that additional failing acceptance tests do not occur which may include, but not be limited to, the following:*

- *Observation of the contractor's sampling and testing procedures for conformance to department procedures and proper testing techniques*
- *Evaluation of the contractor's testing equipment for proper working condition and conformance to the requirements of the appropriate test procedure*
- *Observation of construction procedures for uniformity of effort and results*

Department Certified Asphalt District Inspector (ADI) Responsibilities for Plant Verification

The Department's ADI is the department's official representative. The Department's ADI will visit each plant at a minimum of once per month to verify plant operations and audit the quality of production.

The Department's ADI is responsible for the following:

The ADI will either take a random independent sample or split sample with the contractor during random plant visits for each JMF being produced for state projects. Enough mix shall be sampled to complete the following tests:

1. $G_{mm}$ – TR 327 - Completed during plant visit
2. Gyratory compacted to $N_{design}$ – T 312, TR 304 - Completed during plant visit
3. Mix moisture – TR 319 - Completed during plant visit
4. Loose mix for %AC and gradation – TR 323, TR 309 -Either at plant or district lab.

After aging, the ADI will use the contractor's laboratory equipment to perform the required test to specifications in table 502-6.

The ADI will indicate in the Department's tracking software whether the sample is independent of the contractor's or a split sample with the contractor. The DOTD inspector shall perform test independently of the contractor. The cooled gyratory briquettes will be tested for bulk specific gravity $G_{mb}$ . $V_a$, %$G_{mm}$ @ $N_{des}$, VFA and VMA.

The District Lab will conduct statistical analysis for variances and means using F and *t* tests at a level of significance of 0.025. If the paired *t* test detects a difference, the IA team shall investigate to identify the source of difference. The inability to reconcile will justify the Department requirement to use an independent certified lab to perform the contractor's testing at the plant.

The inspector shall also take a verification sample a minimum of one per month to be tested at the district lab for $G_{mm}$ and voids (gyratory compacted to $N_{design}$ to be made at the district lab). If the AC content or gradation are in question, mix for testing at the district lab shall also be taken for verification of plant tests.

Individual sample test results shall meet the parameters of Table 502-04.

Table 502-04 Plant Inspection Requirements

| Parameters | Tolerances [1] |
|---|---|
| Plant Run Volumetrics | |
| $G_{mm}$ | ± 0.015 |
| $G_{mb}$ | ± 0.024 |
| Voids, percent | ± 1.3 |
| VMA, percent | ± 1.1 |
| | |

| | |
|---|---|
| District Lab Run Extraction | |
| AC, percent | ±0.2% |
| No. 4 | ±4% |
| No. 8 | ±3% |
| No. 200 | ±0.7% |

[1] Volumetrics Tolerances based on the latest QC average, ( “rolling 5” )

If the tolerances listed in the table above are not met, the Department’s ADI will revisit the plant and test split samples. Split samples will be tested by the Department’s ADI and contractor’s certified technician using the same equipment until such time as a solution is found.

In addition, Quality Control charts, equipment maintenance logs, proficiency sample records, or other record keeping required for certification will periodically be reviewed.

The Department’s ADI is also responsible for ensuring that the plant equipment and processes are in accordance with Section 503.

### 1. Asphalt Cement Properties

The Department’s ADI will sample all asphalt cement working tanks for verification, once per plant visit per grade, and submit for testing to the District Laboratory.

The Materials Laboratory will request refinery verification samples through the District Laboratory. The District Laboratory will coordinate refinery transport delivery with contractor production to ensure Materials Laboratory sample request are met.

Samples shall be clearly identified with the following:

- State Project No.
- Plant Code
- Asphalt Cement Grade
- JMF Sequence Number
- Lot Number
- Sample ID Number

The District Laboratory will test and report Dynamic Shear and phase angle. One Rotational Viscosity per grade per month per refinery will be tested by the District Laboratory. If the sample meets all criteria, production continues.

Should the working tank sample fail, the district laboratory will promptly notify the project engineer and the contractor. The contractor shall notify the supplier. Additionally, the DLE must investigate to determine the cause of failure. The following is general guidance for investigating failures:

- Compare working tank results to refinery results, transport results, and previous working tanks results. Does this material have a history of problems that would have resulted in similar problems?
- Send samples to the Materials Laboratory for complete analysis

- Check maintenance schedules for the working tank to find out what was done. When the coils were last cleaned? When the tank was last cleaned?
- Inspect facilities, checking the history of the supplier material, etc.
- Check the temperature on the working tank.
- Check whether or not a different brand or grade of material has been added to the tank. Was the tank drained sufficiently before adding new material?
- Test rotational viscosity

If it is determined that material in the working tank does not meet specification requirements, then plant production shall cease until corrections are made.

Asphalt cement in the plant's working tank shall meet the specifications of the asphalt cement required on the JMF.

### 2. Percent Anti-Strip

An anti-strip additive shall be added to all mixtures at no less than the minimum rate on the approved Job Mix Formula.

The Department's ADI will test for the amount of anti-strip. If the check performed indicates that the amount of anti-strip added is not in accordance with the JMF, the contractor must make adjustments so that the correct amount of anti-strip additive will be added to the mixture. If the second check indicates that the mixture is still not receiving the correct percentage of anti-strip, production for DOTD projects shall be terminated until adequate adjustments can be made to the system or the system can be recalibrated.

The results of the percent anti-strip (i.e. 0.6% by weight) will be entered into the Department's approved software. These reading are to be reported once per 5 P-Lots by the contractor.

The basic method of checking the percentage of anti-strip in the mixture is to monitor the flow of additive for a continuous time sufficient to represent approximately half a lot. In order to proceed with the calculations for the percentage of anti-strip, the certified technician must know the unit weight of the anti-strip additive at any given temperature. The anti-strip supplier must make the unit weight information available or a one-gallon sample may be weighed at the plant to determine this value.

An example of determining percentage of anti-strip added to HMA follows:

1. Temperature - Read and record the temperature of the anti-strip additive being added to the mixture from the thermometer on the anti-strip tank.

2. Readings - Take an initial reading of the amount of anti-strip additive from the anti-strip meter and take an initial reading from the asphalt cement totalizing meter. **It is required that the percent asphalt cement and the percent anti-strip be checked simultaneously during continuous production to evaluate the quality of the mixture in terms of both components.**

a. For anti-strip, record the initial reading to the nearest readable increment (0.1 gallon, 0.25 gallon, or 0.034 gal). Allow the plant to run for a continuous period of time sufficient to represent approximately half a lot. Take a final reading to the nearest readable increment and record.

b. For asphalt cement, record the reading to the nearest gallon. (Some plants will digitally display the mass of asphalt cement added on the computerized operational controls.) Allow the plant to run for the same period of time as used for AS determination. Take a final reading of AC used and record to the nearest gallon. Subtract the initial reading from the final reading to obtain gallons AC used. Subtract the initial reading from the final reading to obtain the actual amount of anti-strip used during the time period.

3. Calculations) – Calculate the percent anti-strip in terms of the weight of asphalt cement in pounds.

a. Anti-strip Quantity - Calculate pounds of anti-strip:

| | |
|---|---|
| Unit weight of anti-strip | = 7.28 lb/gal (from curve) |
| Gallons anti-strip used during check | = 41.45 gal |

$$7.28 \text{ lb/gal} \times 41.45 \text{ gal} = 301.8 \text{ lb}$$

b. Asphalt Cement Quantity – Calculate pounds of asphalt cement:

| | |
|---|---|
| Gallons AC used during check | = 5820 gal |
| Weight of 1 gallon of water | = 8.34 lb/gal |
| Specific Gravity of AC @ 60°F | = 1.03 |

$$5820 \text{ gal} \times 8.34 \text{ lb/gal} \times 1.03 = 49{,}994.964 \text{ lb}$$

c. % Anti-strip - Calculate the percent anti-strip:

$$\% \text{ AS} = \left( \frac{\text{pounds of anti-strip}}{\text{pounds of asphalt cement}} \right) \text{x}100$$

$$\% \text{ AS} = \left( \frac{301.8}{49{,}994.964} \right) \text{x}100$$

$$= 0.604$$

$$= 0.6 \text{ \% anti-strip}$$

Report the final percentage of anti-strip additive to the nearest 0.1 percent.

4. Alternate Method – An alternate method is to take a printout of anti-strip and asphalt cement quantities at a specific start and stop point in time from the control room. Divide the total anti-strip quantity for that period of time by the total asphalt cement for the same period of time. Results shall be within ±0.1 of the JMF. If not, production shall be discontinued until the proper rate can be added.

If lime or other additive types are being proportioned in the HMA mixture at the plant (and shown on the JMF) then this rate shall also be verified, via the plants meters/scales.

3. Volumetrics

Assume 5 samples taken from 5 consecutive P-lots of continuous production of the same mix from a plant.

| | | |
|---|---|---|
| 5000 TONS | ¾" NMS Wearing | Category B Roadway |

VOIDS – Spec Limits are 2.5% to 4.5%.

Test results are:

| | | | | |
|---|---|---|---|---|
| 2.3% | 2.2% | 3.0% | 2.9% | 3.0% |

VOIDS – Compute PWL for 5 voids results.
First compute the mean and the standard deviation. The formula used to determine the mean is:

$$\text{Mean} = \overline{X} = \frac{X_1 + X_2 + X_3 + \ldots + X_n}{n} = \frac{\sum_{i=1}^{n} X_i}{n}$$

Using our example,

$$\text{Mean} = \overline{X} = \frac{2.3 + 2.2 + 3.0 + 2.9 + 3.0}{5} = \frac{13.4}{5} = 2.68$$

Now compute standard deviation. The formula to determine standard deviation is:

$$\text{Standard Deviation} = s = \sqrt{\frac{(X_1 - \overline{X})^2 + (X_2 - \overline{X})^2 + .... + (X_i - \overline{X})^2}{n - 1}}$$

$$= \sqrt{\frac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n - 1}}$$

$$\mathbf{s} = \sqrt{\frac{\mathbf{(2.3 - 2.68)^2 + (2.2 - 2.68)^2 + (3.0 - 2.68)^2 + (2.9 - 2.68)^2 + (3.0 - 2.68)^2}}{\mathbf{5 - 1}}}$$

$$\mathbf{s} = \sqrt{\frac{\mathbf{0.38^2 + 0.48^2 + 0.32^2 + 0.22^2 + 0.32^2}}{\mathbf{5 - 1}}}$$

$$\mathbf{s} = \sqrt{\frac{\mathbf{0.1444 + 0.2304 + 0.1024 + 0.0484 + 0.1024}}{\mathbf{5 - 1}}}$$

$$\mathbf{s} = \sqrt{\frac{\mathbf{0.6280}}{\mathbf{5 - 1}}}$$

$$\mathbf{s} = \sqrt{\frac{\mathbf{0.6280}}{\mathbf{4}}}$$

$$\mathbf{s} = \sqrt{\mathbf{0.1570}}$$

Using our example, $\mathbf{s} = \mathbf{0.396232}$

$$\mathbf{s} = \mathbf{0.3962}$$

**Note**

When performing computations, please note that the significant digits for the average will be one more place than the significant digits for the value. Also, the significant digits for the standard deviation will be two more than the significant digits for the average. For example:

| | |
|---|---|
| Voids is x.x | Density is xx.x |
| Voids Average is x.xx | Density Average is xx.xx |
| Voids Standard Deviation is x.xxxx | Density Standard Deviation is xx.xxxx |

Then compute the Upper Quality Index, $Q_u$, and Lower Quality Index, $Q_{L,}$ using this formula:

$$\text{Upper Quality Index} = Q_U = \frac{USL - \overline{X}}{s} \qquad \text{Lower Quality Index} = Q_L = \frac{\overline{X} - LSL}{s}$$

If the Upper Spec Limit, USL, is 4.5 and the Lower Spec Limit, LSL, is 2.5, then:

$$\text{Upper Quality Index} = Q_U = \frac{4.5 - 2.68}{0.3962} = \frac{1.82}{0.3962} = 4.59$$

$$\text{Lower Quality Index} = Q_L = \frac{2.68 - 2.5}{0.3962} = \frac{0.18}{0.3962} = 0.45$$

Table 502-9 is used to convert the Quality Index into the PWL value. A PWL is calculated for each Quality Index (upper and lower) and combined for a total PWL calculated in accordance with the formula:

$PWL = PWL_L + PWL_U - 100$

where: $PWL_L$ = lower percent within limits
$PWL_U$ = upper percent within limits

The PWL for the five void results will be calculated as follows:

From Table 502-9, using n = 5, the $PWL_U$ which corresponds to 4.59 is 100.

The $PWL_L$ which corresponds to 0.45 is 66.

Applying the formula above, Total PWL = $PWL_U + PWL_L$ – 100 = 100 + 66 – 100 = 66.

From 502.05, Quality Control and Plant Acceptance, the rolling five test must meet 71 PWL. The contractor will take corrective action or cease production.

4. Roadway Quality Control

The contractor shall perform roadway operations in accordance with Subsections 502.07, 502.08 and 502.09. Quality control shall be performed in accordance with Subsection 502.11. The contractor shall constantly monitor equipment, materials, and processes to ensure that density and surface tolerance requirements are met. Quality control testing and inspection shall be sufficient to ensure a smooth and homogenous pavement, free from segregation, truck ends, raveling, tearing, streaking, rutting, cracking, shoving, dragging of rocks, and rippling.

Mixture temperature has a substantial effect on the density of the mat and shall be sufficiently monitored. The contractor shall coordinate the plant production rate with transportation and placement rates to ensure continuous placement of mix. The contractor shall monitor placement to ensure that cross-slope, grade, and transverse requirements are met as specified in Table 502-5, Subsection 502.11, and the Materials Sampling Manual.

a) *Density*

A non-destructive density machine shall be utilized to establish a rolling pattern and monitor density. When setting rolling patterns, the contractor will achieve longitudinal joint density within 3 percent of the rest of the paving strip. Joint density will be ≤ 2 feet of the joint and a non-destructive testing device will be used across the paving strip. Surface Tolerance (Transverse and Longitudinal) See Chapter V of this manual and section 502.12, Surface Tolerance Equipment, Quality Control, Acceptance, Measurement and Payment Adjustments.

The contractor shall report the values from setting the rolling pattern in the department's approved software.

## E. Roadway Inspection

### 1. Inspection of Mixture on Roadway

Department personnel shall visually inspect the HMA product. The Certified Inspectors are to evaluate the mixture both at the plant and at the jobsite. Mixtures exhibiting the following deficiencies shall not be placed:

- segregation,
- contamination,
- lumps,
- non-uniform coating,
- excessive temperature variations and
- other deficiencies

Mixture contamination, alignment deviations, variations in surface texture and appearance or other deficiencies apparent on visual inspection will not be accepted. Poor construction practices such as inadequate handwork, improper joint construction or other deficiencies apparent on visual inspection will also not be accepted. Deficiencies revealed by visual inspection both after placement and before final acceptance shall be corrected at the contractor's expense.

If a load of HMA material is suspected of deficiencies, but is allowed to be placed, the paving inspector will sample the HMA for testing. The paving inspector will document the exact location where the suspect material was placed. Materials identified as being deficient may require subsequent removal and replacement.

The Department personnel are to observe haul trucks for conformity to certification. If haul trucks are not maintained to truck certification standards, they shall not be allowed on state projects. Areas of observation are:

- Tight fitting tailgates
- Dump beds – tight, clean and smooth
- Tarps – canvas or vinyl large enough to cover the top and extend over the sides. (Sand tarps not allowed)
- Sufficient tie-downs to secure the tarp.
- Certification sticker(s) are legible
- No fuel or fluid leaks
- Diesel shall not be allowed in dump beds

The DOTD Certified Paving Inspector at the laydown site is responsible for observing the performance of surface tolerance testing, checking lane widths and other grade and alignment checks and equipment suitability. In addition, the Certified Paving Inspector is responsible for maintaining a running total of tonnage delivered to the project from each plant P-Lot. The inspector must also document the beginning and ending limits of each lot as it is placed on the roadway. Continuous records of lot placement should be maintained in a field book. The Certified Paving Inspector will check yield on a continuing basis during the project and calculate the yield for each portion of a lot delivered to the roadway. Beyond these duties, the Certified Paving Inspector must observe the appearance of the mat behind the paver and the rollers, the uniformity and acceptability of joint construction and the performance of the paving train equipment. If material related problems occur at the jobsite, then the Certified Paving Inspector shall make immediate contact with the Department's ADI so that adjustments can be made in the manufacturing and transport processes.

It should be noted that P-lots delivered to a project may not contain ~1000 tons. P-lots can be shipped to multiple projects by the contractor.

**Discarding Material**) – When dumping HMA into the MTV, it may be necessary to discard approximately 200 to 300 pounds of material. This material shall be disposed of by the contractor/producer outside the limits of the right-of-way upon completion of the project. No deduction in lot tonnage totals shall be made for this material waste. However, the paving inspector is to continually monitor the truck dumping operation to assure minimal waste.

The following headings address essential inspection points. This list is not intended to be comprehensive or to exclude any other area from regular inspection. It is merely intended to serve as a guide to the field inspector in the performance of his/her responsibility.

Ensure that the contractor must have adequate incidental equipment such as rakes, tamps, lutes and shovels for the work being performed available at the project. This equipment must be clean and in satisfactory condition.

**Lumps, Contamination, Coating -** Any material that is not properly coated, has lumps, or is contaminated will be rejected prior to placement. Lumps may be indicative of moisture problems or a dryer/drum that needs to be cleaned out. If the paving inspector observes this deficiency, the inspector is to notify the contractor, DLE, and/or ADI. Operations shall be discontinued and the dryer/drum cleaned. A mix that is not properly coated will be sampled and a Ross Count performed (DOTD TR 328). Contaminated material will also be sampled. When sampling a material for future Department investigation, the inspector must be certain to obtain a sample that is representative of the questionable material.

**Temperature** - The paving inspector is also responsible for verifying that the temperature of the material at the roadway is within specification tolerance. The temperature of the material in the truck shall be within 25° F of the bottom limit of the job mix formula (JMF). If the temperature is outside this tolerance or exceeds the upper JMF temperature limit, it is out of specifications and shall not be placed. The paving inspector will record the job site temperature and tonnage rejected on the back of the haul ticket and void the ticket. The paving inspector will immediately notify the contractor, DLE and/or ADI and check each subsequent truck until the material temperature is again within acceptable limits.

The material temperature will be recorded on the back of the haul ticket. The temperature of the mix going through the paver shall not be cooler than 245° F. In such cases, the temperature of the material and the tonnage discarded will be documented on the back of the haul ticket and the payment quantity adjusted.

**An infrared thermal heat sensing device (temperature gun) shall not be used for temperature acceptance. If questionable temperatures are measured using an infrared device, they shall be verified with a calibrated dial (stick) thermometer.**

The first three loads of a JMF for a project may be above the JMF limits but in no case greater than 350º F. This allows for startup at the plant and for heating the MTV and paver at the beginning of paving operations.

### 2. Yield

**Theoretical Yield** – The estimated quantity of HMA shown on the plans is the amount that should be used on the project based on a mixture that weighs 110 pounds per square yard per inch of thickness. If the project is constructed in accordance with the dimension and mat thickness shown on the plans, this plan quantity should be accurate. If less HMA is used than called for by the plans, the mat will probably, on the average, be too thin.

If more HMA is used than called for by the plans, the mat will probably, on the average, be too thick. Additionally, a cost overrun will result. Failure to keep the actual quantity of HMA used fairly close to plan quantity may require a plan change. If extra material is needed for minor adjustments due to field conditions, it is imperative that current departmental policy for overruns be strictly followed.

The plan quantity is always calculated on HMA material weighing 110 lb/sq yd/inch thickness. However, some aggregates such as sandstone or slag will cause the unit weight of the mixture to differ from the standard 110 lb/sq yd/inch value.

To take this weight difference into account, the department has established weight-volume adjustment factors to determine the theoretical yield of an HMA material with a theoretical maximum specific gravity ($G_{mm}$) outside the range of 2.400 – 2.540. These factors (from the *502.14 Standard Specifications)* are shown in the following table.

**Adjustment Factors**

| **Theoretical Maximum Specific Gravity, ($G_{mm}$) (AASHTO T 209)** | **Adjustment Factor (F)** |
|---|---|
| 2.340 – 2.360 | 1.02 |
| 2.361 – 2.399 | 1.01 |
| 2.400 – 2.540 | 1.00 |
| 2.541 – 2.570 | 0.99 |
| 2.571 – 2.590 | 0.98 |

The adjustment factor (F) for mixtures with theoretical maximum specific gravities ($G_{mm}$) less than 2.340 or more than 2.590 will be determined by the following formulas:

Theoretical Maximum Specific Gravity ($G_{mm}$) less than 2.340:

$$F = \frac{2.400}{S}$$

Theoretical Maximum Specific Gravity ($G_{mm}$) more than 2.590:

$$F = \frac{2.540}{S}$$

Where,

F = quantity adjustment factor
S = theoretical maximum specific gravity ($G_{mm}$) on JMF

Example:

Theoretical maximum specific gravity is 2.320.

$$F = \frac{2.400}{2.320}$$

F = 1.0345 = 1.03

**The theoretical maximum specific gravity ($G_{mm}$) can be found on the approved job mix formula.**

For HMA materials with an adjustment factor other than 1.00, the theoretical yield of the mixture may be determined by dividing the theoretical yield based on 110 lb/sq yd/inch thickness by the applicable adjustment factor.

For example:

If the material being placed has a theoretical maximum specific gravity ($G_{mm}$) of 2.390, the factor of 1.01 will apply. Assume the material is being placed in a 2.0-inch lift.

T = Thickness in inches

Theoretical Yield = 110 x T

Theoretical Yield = 110 x 2.0 = 220 lb/sq yd

$$Adjustment\ Theoretical\ Yield = \frac{Theoretical\ Yield}{Adjustment\ Factor}$$

$$\text{Adjustment Theoretical Yield} = \frac{220\ \text{lb/sq yd/inch}}{1.01}$$

Adjusted Theoretical Yield = 217.8 lb/sq yd

Therefore, a mixture with a theoretical maximum specific gravity ($G_{mm}$) of 2.390 would require 2.2 less pounds (220 – 217.8 = 2.2) of HMA material per square yard for the same volume (2.0 inches thick) as a mixture with a theoretical maximum specific gravity ($G_{mm}$) between 2.400 and 2.540, inclusive.

**These factors are used to adjust pay quantities, which are based on actual tonnage used, documented on haul tickets.** If plan quantity for a project is 11,620 tons and the material placed has a theoretical gravity of 2.390 (factor 1.01), 11504.950tons of this material would be needed to occupy the same volume as a mixture with a theoretical maximum gravity ($G_{mm}$) of 2.400-2.540 (factor 1.00). Therefore, the target tonnage for this project would be 11,504.950 tons. Assuming that this target tonnage is the tonnage used on the project as documented on the haul tickets to calculate payment tonnage, multiply the tons used by the factor 1.01.

11,504.950 x 1.01 = 11,620.000 tons

The contractor will be paid for 11,620 tons of material, which equals plan quantity. If the contractor were to place plan quantity (11,620 tons), the mat would be too thick. Therefore, the factors must be applied when doing yield calculations, to be certain that the correct amount of material is being placed.

Theoretical Yield is also calculated for paving operations expressed as lbs/sq yd/inch. This value can be used in a variety of applications such as:

- Establishing distances that one truck or multiple trucks should cover

- Establishing sub lot and lot limits for travel lanes and shoulders
- Determining the amount of HMA needed for irregular areas, driveways, turnouts, crossovers, etc.

Theoretical Yield is documented in field books and is also a required entry on the *Superpave Asphalt Concrete Pavement Report.*

Below are examples of the different applications. An Adjustment Factor of 1.00 is assumed for all examples:

**Establishing distances that one truck or multiple trucks should cover:**

Weight of Asphalt Concrete in Truck in Tons x 2000
(Width of Paving Strip/9) (110 x Plan Thickness in Inches)

23.60 tons x 2000
(11.5 feet wide paving strip/9) (110lbs x 2 inch plan thickness)

47200.00 lbs)
(1.27 sq yds per linear foot) (220 lbs.)

47200.00 lbs
279.40 lbs per linear foot

168.93 = 169 linear feet that this truck *should* cover

An alternate method of tracking and monitoring yield for trucks is to convert the pounds per linear foot value to tons per linear foot.

279.40 lbs. per linear foot/2000 = 0.139~~7~~ = 0.139 tons per linear foot

This converted value can be easily applied and used as a constant by dividing this value into the tonnage of HMA delivered as reflected on a haul ticket, provided that the width of the paving strip and the plan thickness do not change. Note that there will be a slight difference in distances because of the conversion from pounds per linear foot to tons per linear foot.

23.60 Tons of Asphalt Concrete in Truck
0.139 tons per linear foot

169.78 = 170 linear feet that this truck *should* cover

**Establishing sub lot and lot limits for travel lanes and shoulders:**

**~1000 ton P-Lots are used to track Asphalt Mixtures shipped from the plant. Mainline Roadway lots are linear measurements used to establish pay for Asphalt Mixtures.**

**A roadway lot consists of five 7500 foot sublots totaling 37500 feet.**

Assume that the typical section of a roadway is 24 feet wide and 2 inches thick. The sequence of construction will utilize an 11.5 foot wide paving strip for a standard 1000 ton P Lot. The full width of the roadway would be accomplished by laying an adjacent paving strip of 12.5 feet. Adjacent paving strips may not always be included in the same sub lot.

$$\frac{\text{P Lot in Tons x 2000}}{\text{(Width of Paving Strip/9) (110 x Plan Thickness in Inches)}}$$

$$\frac{\text{1000 Tons x 2000}}{\text{(11.5 foot wide paving strip/9) (110 lbs. x 2 inch plan thickness)}}$$

$$\frac{\text{2000000.00 lbs.}}{\text{(1.27 sq yds per linear foot) (220.00 lbs)}}$$

$$\frac{\text{2000000.00 lbs.}}{\text{279.40 lbs per linear foot}}$$

7158.19 = 7158 linear feet paved from a 1000 ton P-Lot

In this situation, one P-Lot does not pave an entire roadway sublot. Another 47.78 tons would be needed to complete the roadway sublot.

7500 feet (roadway sublot) – 7158 feet paved = 342 feet to end of roadway sublot.

279.40 lbs per linear foot x 342 feet = 95554.8 lbs/2000 lbs per ton = 47.78 tons

**Determining the amount of HMA needed for irregular areas, driveways, turnouts, crossovers, etc.:**

Assume that an overlay project has 25 residential driveways, with each driveway having an area of 15 square yards and a plan thickness of 4 inches.

$$\frac{\text{(Total Area in Square Yards) (110 lbs. x Plan Thickness in Inches)}}{2000}$$

$$\frac{\text{(25 driveways x 15 Square Yards) (110 lbs. x 4 inch plan thickness)}}{2000}$$

$$\frac{\text{(375.0000 sq yds) (440.0000 lbs)}}{2000}$$

$$\frac{\text{165000.0000 lbs}}{2000}$$

82.5000 = 82.50 tons needed

**Actual Yield –** Actual yield is the actual amount of HMA material placed in terms of pounds per square yard. It is the responsibility of the Certified Paving Inspector to maintain a constant check on actual yield during paving operations to ensure that at the end of the project, actual yield and theoretical yield will match closely. Actual yield should be checked and compared to the theoretical yield several times during a paving day, at the end of a lot, and at the end of the project. Since mat thickness is averaged and not exact, actual yield may vary slightly from theoretical yield on an individual truck or even for several truckloads. However, it should never run consistently over or under theoretical yield. If actual yield is consistently over or under theoretical yield, something may not be correct with the paving operation. The contractor will then be required to identify and correct the problem, or the project will not conform to the plans.

The formula for computing actual yield is:

$$\text{Actual Yield} = \frac{\text{Tons Used x 2000}}{\text{Square Yards of Pavement}}$$

Utilizing the example of establishing sub lot limits in the previous section on Theoretical Yield, a comparison against the Actual Yield shall be made and documented on the *Superpave Asphalt Concrete Pavement Report.*

1040 Tons of HMA were used for the P-Lot that was 7158 linear feet and 11.5 feet wide and 2 inches thick.

Square Yards = (7158 x 11.5)/9 = (82317.00)/9 = 9146.33 = 9146 square yards

Actual Yield:

$$\frac{\text{1040 tons Used x 2000}}{\text{9146 square yards}}$$

$$\frac{\text{2080000.000 lbs.}}{\text{9146 square yards}}$$

227.421 = 227.4 lbs/sq yd

Therefore, the difference between the Theoretical Yield of 220.0 lbs/sq yd/plan thickness in inches and the Actual Yield of 227.4 lbs/sq yd used is 7.4 lbs/ sq yd over. This indicates that the mat may be too thick and an overrun for this sub lot has occurred.

One method for determining percent overruns or underruns can be calculated from the tonnage.1000 tons were needed for the area to be paved based on Theoretical Yield for the sub lot. 1040 tons were actually used for the area.

$$\frac{\text{40 Tons Over}}{\text{1000 Tons Needed Based on Theoretical Yield}} \times 100$$

$$.0400 \; x \; 100 = 4.0\% \text{ Overrun}$$

As stated earlier, Actual Yield should never run *consistently* over or under theoretical yield. Overruns or underruns for the Contract Item may require a Change Order in accordance with the *DOTD Construction Contract Administration Manual*.

## F. JOINT CONSTRUCTION

All pavement joints shall be constructed according to the requirements of the specifications. They shall be inspected by the department's inspectors for satisfactory compliance to the department standards in accordance with the procedures described in this manual and the standard specifications.

**Longitudinal Joints** – Department specifications stipulate that, during the construction of a longitudinal joint, no material will be scattered loosely over the uncompacted mat. The overlapped material shall be pushed back to form a vertical edge above the joint. The vertical edge shall then be compacted by rolling to form a smooth, sealed joint. When setting rolling patterns, the contractor will achieve longitudinal joint density within 3% of the rest of the paving strip. Joint density will be ≤ 2 feet of the joint and a non-destructive testing device will be used across the paving strip.

Coarse aggregate shall not be raked from the HMA mixture at the joint. Excess material or spillage shall not be pushed onto the uncompacted mat. If workers cast the overlap onto the uncompacted mat, this material will be segregated and not visually appealing. Such material will ravel under traffic. If this occurs, the inspector must require that the material be removed from the fresh mat before the roller approaches the area.

After compaction, a properly constructed longitudinal joint should not be high or low when compared to the adjacent mat. There should be no rough material at the joint location. The joint must be properly sealed. There can be no opening allowed between the mats. The joint should not overlap onto the previously compacted mat. After compaction, the inspector must check the joint for all applicable points. The inspector should also place a 10-foot static straightedge across the joint, transverse to the centerline. If there is any deviation greater than the transverse surface tolerance applicable to that course listed in Table 502-5 of the *Standard Specifications*, corrective action will be required. Checking the joint with a 10-foot static straightedge is effective on a tangent slope, but will not work on a two-lane roadway with center crown. For a roadway with center crown, the inspector will place a ten-foot static straightedge across the joint with approximately one foot resting on the new mat. If the fluff was not adequate, there will be a dip at the joint and the paver shall be adjusted.

**Transverse Joints** – A transverse joint must be formed whenever paving operations are discontinued long enough for the temperature of the HMA material being placed to fall more than 50° F from the lower limit of the JMF. This includes the interruption of paving operations at the end of the day. Equipment malfunctions, plant problems, or weather conditions can also cause an interruption of the paving operations, which will require construction of a transverse joint.

The inspector will visually inspect the joint longitudinally and transversely to determine if there are any apparent deviations in the area. The inspector will then place a ten-foot metal static straightedge at several locations across the joint location and attempt to push a shim the thickness of the applicable specification deviation beneath the straightedge. The joint shall comply with Subsection 502.07.3.2.

If the transverse joint does not meet specification requirements, the contractor shall correct it before the paving operation proceeds. The paving operation shall not proceed further than 100 feet from the transvers joint until the transverse joint meets specifications. Only the minimum amount of handwork required to correct the deficiency will be allowed and only the affected area shall be worked. This handwork must also be completed so that the area can be recompacted before the mat surface has cooled beyond the point where compaction cannot be achieved. If the deviation at the joint is excessive (i.e., beyond that which can be satisfactorily repaired with a minimum amount of handwork) the contactor will be required to completely remove the material placed and reconstruct the joint with the paver.

After any required corrections have been completed and the area recompacted, the inspector must recheck the joint to ensure that the corrective action has met all Department surface finish requirements and that the surface texture of the corrected area is acceptable. If the inspector is still unable to approve the joint, the contractor must take additional corrective measures.

## G. SEGREGATION

If the material appears to be segregated in the truck, the inspector shall determine if the degree of segregation is severe enough to warrant rejection. If the load is placed, the inspector is to sample the material for subsequent testing. If the material appears segregated in the truck, the inspector must check the mat carefully behind the paver. If segregation is apparent, the inspector shall notify the Project Engineer and the ADI. Future trucks showing segregation will be rejected until the problem is corrected. If material does not appear segregated in trucks, but the mat exhibits segregation, the inspector shall require the contractor to identify and correct the problem immediately. If the problem cannot be corrected, operations shall be discontinued. Segregated areas of compacted HMA mat will be subject to Department investigation for acceptability and may have to be removed and replaced at the contractor’s expense.

As previously stated, Section 503.14 of the *Standard Specifications* requires the use of a material transfer vehicle (MTV) when placing the final two lifts of HMA on the roadway travel lanes. The three main objectives in requiring the MTV are to reduce HMA segregation, improve surface smoothness, and promote continuous, non-stop paving. However, HMA materials may be placed without the use of the MTV when placing base course mixtures, leveling, and shoulders or as allowed by Subsection 503.14. In any case, the Certified Paving Inspector should continually monitor the finished mat for any segregated area.

When paving without an MTV (dumping HMA directly into the paver hopper from the haul truck), proper truck exchange is critical to the production of a smooth, uniform mat. The truck should never bump the paver and should not rest on the paver hopper. Material should not be dumped or spilled in front of the paver. The material should be dumped into the paver in a large mass to prevent segregation.

**Segregation on Mat** - Segregated areas of the mat will have a different look than the rest of the roadway surface. These areas will be more open-textured. The size of these areas will vary depending on the severity of the cause. It is not uncommon for such open-textured area to be 30 feet long and the full width of the paver, although many of these areas are confined to 15-foot lengths and just the center two-thirds of the paver's width. These areas have a tendency to become more noticeable after being exposed to traffic and can best be observed when the angle of reflective light is low (i.e., early morning or late evening) or just after a rainfall. Under these conditions, these open-textured areas remain wet and dark looking when compared to the drier surrounding areas.

**Truck Ends** - Truck end segregation is caused by the coarse aggregate fractions separating from the fine aggregate fractions either in the production, transport or laydown processes. In severe cases, this separation can be observed at the plant when noticeable roll-down of the coarse aggregate occurs toward the sides, the tailgate and the cab area of the haul unit. Such roll-down segregation results in a truck end in one or more of the following ways.

- The segregated roll-down material at the tailgate is fed onto an empty slat conveyor and fed back to the paver augers as segregated material, causing a truck end.

- The segregated roll-down material on the sides of the haul truck is fed into the wings of the paver hopper. When these wings are dumped (i.e., the material in the wings is fed to the slat feeder), this segregated roll-down material will cause a truck end.

- The segregated roll-down material at the cab end of the truck (which is the last to be fed from the truck) will roll down the entire length of the bed, and if fed by itself to the augers, will cause a truck end.

Numerous investigations have identified the material at truck end locations to be inferior in quality, possessing low asphalt content, with an extremely coarse gradation and a low roadway density. **The net result of these poor mix qualities is an area of roadway that will crack and/or ravel if used as a wearing course or be structurally deficient and subject to moisture damage if used as a binder or base course.** Beyond the poor mixture characteristics associated with these truck end segregations, a poor ride is most often the result. This poor ride is identified by dips at the same intervals previously described. These dips are due to either a paver's screed settling on the coarse mix during construction (i.e., a mixture with high air voids offers less resistance to the screed) or the dips develop later under traffic, when these high-void areas which have low initial density are compacted more than the well-compacted areas immediately adjacent.

Regardless of where the segregation is first observed, truck end segregation areas on the roadway are to be eliminated or minimized to the best degree possible.

It is an important point to remember that the material is segregating through whatever handling processes it is being subjected to (e.g., coated in a dryer/drum, conveyed into a surge/storage silo, emptied into a large trailer truck and dumped onto a paver's empty slat feeder). It is an equally important point to know that some well-graded and well-coated mixes do not segregate given an identical handling process. Consequently, all attempts to eliminate or effectively minimize truck end segregation have not been taken until one or more mixture, process, and handling changes have been tried and implemented.

The following steps should be taken whenever segregation is observed:

- Paver wings should not be dumped until the end of the paving day. HMA materials dumped from paver wings shall be discarded and not incorporated into the roadway.

- Haul trucks should be loaded with the minimum of three drops, the last of which shall be in the middle of the bed. It is the intent of this loading procedure to first load as close to the tailgate and cab areas as possible to minimize roll-down and then complete the load in the middle of the bed.

- During the exchange of trucks at the paver (when no MTV is required), the level of material remaining in the paver hopper should not drop so low as to expose the hopper feed slats. Keeping the slat feeders covered with material will aid the mixing of whatever roll-down material exists with non-segregated material before it is fed to the paver augers.

- The paver augers should be run at minimum revolution to reduce segregation. Further, the level of material should be maintained to at least that of the auger shaft. Augers should run at least 95% of the time.

Any segregated areas on the roadway which occur at regular intervals must be eliminated or effectively minimized. The paving inspector must be aware of the potential problem and maintain constant communication with the production and paving personnel when a problem exists. The project engineer will instruct the contractor/producer to correct problems associated with segregation.

## H. COORDINATION OF PAVING OPERATIONS

**Coordination of Paving Operations with Production and Transport** - One of the most important elements of successful HMA paving operations is the coordination of paving speed to plant production and hauling capacity. A start and stop operation will not produce a uniform mat and smooth riding surface. A start and stop paving operation is specifically prohibited by the specifications. The *Standard Specifications* require the contractor/producer to coordinate and manage plant production, transportation of HMA, and laydown operations to ensure reasonably continuous plant and paving operations with minimum idle time between loads. Delivery of the material to the paver must be at a uniform rate. There should be no waiting time between truckloads; nor should a large number of trucks be waiting to discharge into the paver or MTV. The correct speed for the paver is such that as one truck empties and pulls away, one truck is waiting to move into discharge position immediately. If sufficient hauling vehicles are not available to maintain a smooth, coordinated paving operation, the specifications authorize the discontinuance of operations or requirement of additional trucks. Paver speed and plant production should also be tied to time required for rollers to achieve compaction in the paving train.

## I. Analysis of Plant and Roadway Test Data in the Acceptance Decision

*F*-test and *t*-test Method for Comparing Two Sets of Data*

*F* (variances) and *t* (means) tests are two hypothesis tests used to compare two sets of data. In this case contractor and DOTD test results. The *F*-test provides a method for comparing the **variances** of two sets of data. Differences in **means** are assessed by the *t*-test.

For samples from the same normal population, the statistic *F*, which is the ratio of the two sample variances, has a sampling distribution called the *F*-distribution. For process verification testing, the *F*-test is based on the ratio of the sample variance of the contractor's test results and the sample variance of DOTD test results.

The *t*-statistic and the *t*-test can be used to test whether the sample mean of the contractor's test results and DOTD test results came from populations with the same mean.

When comparing contractor and DOTD samples, it is important that proper **random sampling** is utilized. Because sources of variability influence the population parameters, the two sets of test results must be sampled over the same time period, and the same sampling and testing procedures must be used. If it is determined a significant difference is likely between either the variances or the means, the source of the difference should be identified. The identification of a difference is just that, i.e., notice that a difference exists. The reason for the difference must be determined.

The level of significance used for comparison of contractor and DOTD results is 0.025.

The values used for the *t*-test are dependent upon whether or not the variances are assumed equal for the two data sets. This makes it necessary to test the variances before the means. *F*-test before the *t*-test. The intent is to determine whether the difference in the variability of the contractor's tests and DOTD tests is larger than might be expected by chance if they came from the same population. It does not matter which variance is larger. After comparing the *F*-test results, one of the following will apply:

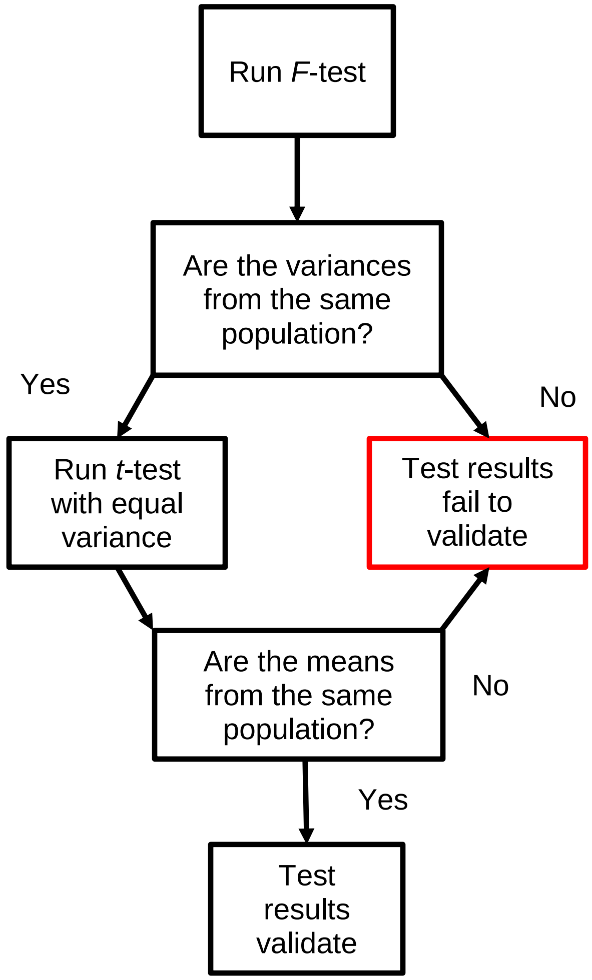
- The two sets of data have different variances because the difference between the two sets of test results is greater than is likely to occur from chance if their variances are actually equal.

- There is no reason to believe the variances are different because the difference is not so great as to be unlikely to have occurred from chance if the variances are actually equal.

After the variances have been tested (*F*–test) and showing no statistical difference, the means (*t*-test) shall be run to determine whether the mean differ. The goal is to determine whether it is reasonable to assume the contractor's tests came from the same population as the agency's tests.

*excerpted from FHWA-RD-02-095

Flow chart for *F* and *t*-test:




The minimum number of samples per JMF:

Acceptance = 45

Verification = 15

## 1. Plant Acceptance

The contractor must demonstrate that the plant processes are under control for voids and $G_{mm}$. The contractor will report the P-lot data to the DLE daily. The DLE will verify processes by applying the following rules:

a. One point is more than 3 standard deviations from the mean.
b. Nine (or more) points in a row are on the same side of the mean.

If the process is determined to be out of control further inspection will be required.

The Contractor shall continuously enter the test results of plant data as it is produced. As a minimum, the following records shall be kept on file at the plant laboratory:

Report the results of each individual test and the moving average for five samples and corresponding standard deviation for all parameters in the current DOTD tracking software. Maintain the moving average within specified limits for $G_{mm}$, air voids, VFA, VMA, percent $G_{mm}$ at $N_{initial}$, required gradation parameters, and asphalt content for the last five samples tested. Discontinue production when any average of five falls outside the specifications limits. Make notes of proper adjustments for permanent record prior to continuing production.
Determine the percent within limits (PWL) for rolling average of five P-lots of plant produced mixture for the Nos. 8 and 200 sieves and for $G_{mm}$.

The contractor shall maintain mixture testing tolerances within the ranges specified on the following table:

**Tolerances for Rolling Five Average**

| Parameters | Tolerances[1] |
|---|---|
| $G_{mm}$ | ± 0.015 |
| $G_{mb}$ | ± 0.024 |
| Voids, percent | ± 1.3 |
| VMA, percent | ± 0.5 |
| AC, percent | ± 0.3 |
| VFA | ± 1.0 |
| Gradation | |
| No. 4 | ± 6 |
| No. 8 | ± 5 |
| No. 200 | ± 1.2 |

[1] Based on the latest QC average, ( “rolling 5” )

If the quality control data show that the mixture being produced is not uniform, the Contractor shall correct operations and produce a uniform mixture or discontinue operations for DOTD.

Production adjustments resulting in subsequent production tolerance adjustments will require a new JMF should they exceed:

- 7% of cold feed proportions
- 0.3% virgin asphalt content

Maintain daily record of cold feed percentages and asphalt content settings.

**NOTE:**

During production, cold feed adjustments to JMF mixture proportions may be made. When any adjustments beyond ±4% for coarse or fine aggregate are made, from the initially submitted JMF values, the District Lab Engineer shall be notified.

The Contractor shall document all corrections to control the mixture and prevent any aspect of the mixture from moving outside specified limits or from varying erratically within those limits. This documentation shall include the action taken, date and time, and be initialed by the Contractor.

## 2. Roadway Acceptance

Roadway lot pay will be based on tons received on the roadway and pay adjustments will be based on Pavement Density calculated by method shown below. Surface Tolerance pay adjustment will be calculated at the end of the job.

All cores will be cut in the presence of a DOTD inspector and may be trimmed by the Contractor at the project site with approval of the DLE and in the presence of a DOTD inspector. Roadway cores will be identified with letters of the alphabet. Acceptance, verification and resolution cores will be identified with consecutive letters in the alphabet. Example: Sublot 1; 3 acceptance cores will be A,B, and C. The verification core will be D and the resolution core E. Sublot 2; 3 acceptance cores will be F, G, and H. The verification core will be I and the resolution core J. etc…..

*Density*

(1) Method 1, District Laboratory Acceptance

**Core Sampling**

Upon completion of compaction procedures, cores shall be taken in accordance with Subsection 502.11. Sampling shall be performed using the random number tables shown in DOTD S605 in the Materials Sampling Manual or the random number generator in MS Excel® 2010 or later. If a shoulder ≤4 foot is paved with a travel lane, it shall be a separate minor lot based on theoretical quantity.

Core locations shall be marked on the pavement by the Certified Roadway Inspector. Coring shall be performed within 18” of the marked location. When the Project Engineer or DLE request investigative coring, the coring shall be performed at the marked location.

The Certified Roadway Inspector shall list the generated random numbers on the Roadway Report.

The DOTD paving inspector, along with the Contractor/Producer coring representative, will inspect the cores for acceptability and label them for identification. The DOTD inspector and the Contractor in the field, upon inspection and mutual agreement, reserve the right to reject any core(s). It is intended that the acceptance and resolution cores be delivered to the District Lab. The Contractor’s verification cores will be delivered to the plant lab. Deliver all cores on the same day as they are taken, so that the results for acceptance and verification can be made available to the project engineer and Contractor in a timely manner. Expect District Lab acceptance results no later than two days after the Contractor verification core report.

Here is an example of core sampling determination.

- First determine acceptance core location by randomly selecting one core every 2500 feet.
- Then select the verification core location by randomly selecting one core every 7500 feet.
- Finally select the resolution core location by randomly selecting one core every 7500 feet.

Assume sublot has 7500 linear feet of Mainline Mix of continuous production. Listed tonnage based on field conditions in place. Tonnage placed is independent of linear roadway lots.

Tonnage shall be tracked by station to station methods and entered into Daily Diary Records. Haul Tickets shall be tracked according to P-lot, JMF, mix type, mix use and mix placement. Tonnage should correlate to the linear roadway lot of 37,500'. In the event of a pay adjustment, in place tonnage tracking must be accurate.

Roadway Sublot Sampling and Testing

| **Acceptance Core Location** | **Acceptance Core Location** | **Acceptance Core Location** |
|---|---|---|
| 2500 feet of 2 inch pavement 12 feet wide = 358 tons received on the road | 2500 feet of 2 inch pavement 12 feet wide = 371 tons received on the road | 2500 feet of 2 inch pavement 12 feet wide = 365 tons received on the road |
| Verification Core Location<br>7500 feet | | |
| Resolution Core Location<br>7500 feet | | |

Total number of Mainline Mix cores = 25 per lot
Total cores for acceptance as tested by DLE = 15 per lot
Total cores for verification tested by contractor = 5 per lot
Total cores for resolution held for lots that do not verify = 5 per lot

Compute PWL on roadway density using DOTD system, ref Appendix.

**NOTE:**

**To ensure that the cores are sufficiently free from moisture, they shall be placed in a force draft oven at 125° F until a constant mass is ensured in accordance with DOTD TR 304.**

Pavement density must be determined using the Validated JMF theoretical maximum specific gravity, $G_{mm}$ and the Bulk Specific Gravity, $G_{mb}$. The 15 acceptance core density will be calculated using the Validated $G_{mm}$ corresponding to the JMF and the corresponding core $G_{mb}$. Measure one $G_{mm}$ on one acceptance core after $G_{mb}$ measure. If $G_{mm}$ is within ± 0.024 of the Validated JMF $G_{mm}$, accept the lot. If not measure two additional $G_{mm}$'s and average. If average is within ±0.024 of Validated JMF $G_{mm}$, accept the lot. If average $G_{mm}$ exceeds ± 0.024 of the Validated JMF $G_{mm}$, measure resolution cores at independent lab or lab mutually agreed upon between DOTD and contractor. In cases that do not verify, $G_{mm}$ from resolution cores will be used for pay. Pay per PWL.

If the sample obtained from a pavement sublot is less than 1 3/8 inches thick, the Department's Certified Paving Inspector will reject the core and select another sampling location for that sublot by reapplication of the Random Number Tables. The DOTD inspector will package the core for transport in accordance with Subsection 502.11.1 and place the original and one copy of the Superpave Asphalt Concrete Roadway Report in the packaging. HMA mixtures placed in *design* layers less than 1 3/8 inches thick shall be compacted by approved methods to the satisfaction of the project engineer and shall not require coring.

The core sample's official thickness measurement will be obtained by taking three measurements spaced uniformly around the circumference of the core and then averaged. The measurements will be taken by a caliper and recorded by the testing technician to the nearest 0.01-inch on the Superpave Asphalt Concrete Roadway Report.

Should a specimen be damaged during coring operations, the core may be taken from a position longitudinally up or down the pavement within five feet.

All laboratories shall be equipped with a saw suitable for sawing HMA pavement cores. This saw may be used to remove base course material (e.g., soil cement and/or curing membrane), different lifts and/or tack. Care must be taken to minimize the amount of material cut and discarded, especially from the upper surface. Cores shall be cut at the lift line to remove tack, but shall not be cut into the tested lift. With approval of the DLE, the contactor may trim roadway acceptance cores in the presence of the Certified Roadway Inspector at the time of coring operations.

The Contractor will evaluate the pavement verification cores for roadway percent density which shall be computed by comparing bulk specific gravity ($G_{mb}$) to the validated theoretical maximum specific gravity ($G_{mm}$,) reported for the roadway sublot (based on roadway core or P-Lot average $G_{mm}$). The % density determined from the contractor verification cores will be used to establish a history of consistency and for contractor verification of $G_{mm}$.

Notes on the determination of the bulk specific gravity ($G_{mb}$) of a pavement core:

*Weighing an object (as we do with an HMA core) to determine its mass in air and its mass in a fluid (as we do in water) whose specific gravity is known yields sufficient data to determine its weight (mass), volume, and specific gravity. Specific gravity is defined as the ratio of the weight* *of a unit volume of the sample to the weight of an equal volume of water at approximately 25° ±1° C, (77 ±1.8° F).*

*DOTD specifies that the $G_{mb}$ be determined by TR 304. The equation from the test method, for calculating $G_{mb}$ is as follows:*

$$G_{mb} = \frac{\text{Weight in Air}}{(\text{SSD Weight} - \text{Weight in Water})}$$

Note for Specimens with Obvious Surface Voids:

*As the size of the external voids in the specimen increase, it becomes difficult to determine an accurate SSD mass, because the diameter of the voids are of such size that the water will run out of them before an accurate SSD mass can be determined. If air pockets are observed on the core surface, there may be a problem with calculation of voids.*

*To account for this, alternate test procedures may be used with approval of the District Laboratory Engineer. One alternate test procedure is AASHTO T 275 – Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin, used for determining $G_{mb}$ when the percent water absorbed by the specimen exceeds 2.0 percent as determined by the following equation:*

$$\text{Percent } H_2O \text{ Absorbed (by Volume)} = \frac{(\text{SSD Weight} - \text{Weight in Air})}{(\text{SSD Weight} - \text{Weight in Water})}$$

*In addition to DOTD TR 304 and AASHTO T 275, there exist two other methods to determine $G_{mb}$ of a cored pavement specimen. One method, the Pure Volume method, is performed by measuring the thickness and diameter of the cylindrical specimen in numerous locations to calculate average values and then using the following formula to determine its volume:*

$$\text{Volume} = \pi \text{ x } \left(\frac{\text{Diameter}}{2}\right)^2 \text{ x Height}$$

*This volume is used in the denominator with dry weight in air in the numerator to determine the $G_{mb}$.*

*The second method, which uses proprietary equipment, involves weighing the submerged specimen in a vacuumed plastic bag to determine a true volume per AASHTO* T 331-07

*In summary, if the Contractor, or the DOTD inspector suspects that $G_{mb}$ values determined via TR 304 are yielding erroneous values, the district laboratory engineer is to be notified and may approve use of these alternate methods.*

(2) Method 2, Contractor Acceptance when approved by the District Laboratory Engineer and Materials Engineer

Contractor acceptance will be the same except as follows:

1) Verification and resolution cores

DOTD will take possession of the verification and resolution cores. The District Laboratory will perform density testing on the verification cores and perform *F* and *t* testing analysis with the contractor acceptance data. After density testing the District Laboratory will randomly choose one of the verification cores to perform $G_{mm}$ testing. If the $G_{mm}$ from this core is not within ± 0.024 of the validation $G_{mm}$ for the JMF, follow procedures in Method 1 for averaging the $G_{mm}$ of two more cores and then resolution measures if the average of three core $G_{mm}$s do not meet the ±0.024 tolerance.

2) Acceptance cores

The contractor will take possession of acceptance cores and perform density testing at the plant laboratory where the mix was produced in accordance to DOTD TR 304. The contractor will promptly report test data so *F* and *t* analysis can be performed. The contractor will not use destructive test methods to determine roadway density. The acceptance roadway cores shall be clearly identified and retained for a minimum of 10 business days after testing is reported to the DLE. The roadway cores will be subject to verification by the DLE.

## J. Measurement and Payment

1. <u>Measurement</u>

Refer to 502.14 of the Standard Specifications

2. <u>Payment</u>

Refer to 502.15 of the Standard Specifications

a) *Density*

(1) Mainline Payment

Once test results have been determined, use Quality Level Analysis in accordance with Subsection 502.13 to determine percent within limits (PWL, see appendix) and Subsection 502.15 to determine pay.

(2) Payment for Mainline Small Quantities

**Mainline mixtures < 5000 ft.** Ensure a minimum of three cores for pay calculations. For project lots between 2500 and 5000 ft, two acceptance cores will be taken every 2500 ft. For projects less than 2500 ft. will require 3 cores. Cores for Projects with less than 200 tons may be waived by the project engineer. Pay on density PWL.

(3) Payment for Minor Mix Quantities

Three cores per 1000 tons or minimum of 3 cores.

(4) Surface Tolerance

Table 502-8. See Chapter V. Project based lane measurement

# Chapter V. Section 502.12 – Surface Tolerance

## A. Profiler Certification

The Materials & Testing Section (MATLAB) certifies Inertial Profilers annually. The Materials Section will contact contractors whose profilers have an established history with DOTD for scheduling the annul certification. Any new contractors shall call the Materials Section at (225) 248-4168 to schedule an appointment for certification. ProVAL software is required to analyze data. ProVAL is available free of charge at **www.roadprofile.com.** During certification, the contractor is required to provide all data collected from the test track to the Materials Section representative. Data is provided to DOTD on a contractor supplied USB storage device and shall contain the following formats: raw data, header file, .ERD and .PRO. Contractors are encouraged to have their equipment (lasers and accelerometer) calibrated by the profiler manufacturer prior to attending the certification.

The DOTD Roadway Inspector shall check cross slope, grade and transverse surface tolerance in accordance with Table 502-5.

## B. Longitudinal Surface Tolerance Testing

Longitudinal quality control testing shall be in accordance with Subsection 502.12. The contractor shall furnish a DOTD Certified Inertial Profiler and measure both wheel paths simultaneously. A wheel path is defined as 3’ (±½’) on either side of the longitudinal centerline of the lane being tested. Each segment of each wheel path must meet the requirements of Table 502-8. Categories are defined in Table 502-8. Individual bumps greater than ¼” are to be corrected in accordance with 502.12.2.

### 1. Pre-op Tests and Observations

The DOTD Roadway Inspector shall ensure that the contractor is using a DOTD Certified Inertial Profiler for quality control and quality acceptance. Profilers must be certified and operated in accordance with DOTD TR 644 and Section 502.12. To verify that the profiler is certified to be used on a job, the DOTD roadway inspector will check the calibration sticker or certificate (*DOTD Profiler Inspection and Certification*). The Certification sticker will display the date of certification, expiration date, high pass and low pass filter settings, collection filter, and the technician certifying the equipment. Inertial Profilers are certified for IRI only. When QC testing establishes that the cross slope is deficient, the contractor shall immediately suspend paving operations

**The profiler settings shall match the certification settings during profiler operation on DOTD projects. Since the settings on the profilers *can* be changed by the operator, it is imperative that the certification settings be verified before accepting data from the contractor. The settings directly affect the data collected. By changing the settings, the data collected can be manipulated.**

**Before a profiler is used,** the following pre-operation tests shall be performed by the contractor, witnessed by the DOTD inspector, each **day of testing:**

**1. Tire Pressure Check -** The distance measuring system of the profiler is based on revolutions of the wheel and the rolling radius of the tire. The rolling radius of a tire is dependent upon the air pressure. A tire that is fully inflated has a larger rolling radius than one that is not fully inflated. Tire pressure affects the number of revolutions made in a given distance. **The tire pressure shall be checked each morning on the cold tire and adjusted if necessary.** The correct tire pressure at which each profiler is to be run may be found on the *DOTD Profiler Inspection and Certification* form. It is also written in the field book for each profiler by the Materials Section on the day of certification. The tires must be inflated to the specified pressure used on the day of certification.

**The profiler should then be driven for 15 minutes to warm the tires prior to testing.**

**2. Vertical Calibration -** This test is performed on a stationary profiler **by placing various plates under the lasers and taking readings at each block height.** Blocks shall have a thickness of 0.25”, 0.50” and 1.00” or 1.00”, 2.00” and 3.00”, depending on make of the profiler. The vertical calibration check ensures that the height sensor is performing properly. The height sensor measures vertical distance from the sensor to the road way**. For a profiler to pass the vertical calibration check, the average difference must be 0.01 or less.** The operator should not be in the unit during this test.

**3. Bounce Test -** It is performed on **a stationary profiler while the operator bounces the unit (according to manufacturer’s recommendation).** This test is performed in order to check that the accelerometers and height sensors are functioning properly. Accelerometers measure vertical acceleration and are mounted above the height sensor. If the sensors are working properly, the unit will filter out any bouncing or excess movement of the unit itself during the actual surface roughness testing. **The display of the results will differ by profiler make. Some profilers will display “pass” or “fail”. Other profilers will show an acceletrometer graph. The rise and fall of the graph lines above and below the zero mark must be symmetrical for the test to pass.**

**4. Horizontal Calibration -** This procedure calibrates the horizontal measuring system of the profiler. This calibration is performed **by running the profiler over a measured distance of a minimum of 528 feet.** The longer the calibration distance, the more accurate the distance measurement will be over the project length. Whoever is going to be in the profiler during the testing process must be in the profiler during the horizontal calibration. The calibration adjusts for weight distribution. **The profiler will display, “calibration successful” or “calibration unsuccessful.” Other profiler makes simply display the distance traveled.**

**5. Odometer Check -** This check measures the distance traveled by the profiler and verifies the horizontal calibration. This test needs to be performed by **running the same measured distance** used with the horizontal calibration. Distance is usually measured by a pulsar attached to the front wheels. Rotation of the wheel is measured by detection of pulses as the wheel rotates and the notches pass. Each pulse is directly associated with a fixed travel distance through the rolling radius of the tire. The results of the odometer check must be within ±0.1 percent of the distance measured.

**NOTE:**

All results of the pre-ops shall be printed (or clearly displayed in data on the USB storage device) and turned in to the DOTD inspector with the data. The date and time of the test will be indicated with the pre-op results.

Surface tolerance quality is determined by an International Roughness Index, (IRI) and is measured in units of inches per mile.

### Surface Tolerance Pay

Once Pre-op Tests and setting verification are complete, the contractor shall measure and report the average IRI value for each wheel path on every 0.05-mile (0.08 km) segment of highway with the DOTD inspector present. At the completion of the run for pay the contractor's inspector will provide the DOTD inspector with a copy of the results on a USB flash drive and a hard copy. The IRI values for the inside and outside wheel paths shall be averaged and reported as the segment average and the mean of each segment average shall be reported as the project average. Pay adjustment for the project is determined in accordance with Table 502-8 using the average IRI.

Correct all individual bumps which are more than ¼" when tested with a 10 foot metal static straightedge. Utilize the Profilograph Simulation on ProVAL set to look for ¼" bumps in 10' using the 1.97 Butterworth Low-pass filter. The contractor will then provide a copy of the run that was used to the PE for his agreement of areas to be corrected as required in the table. Once the areas to be corrected are agreed upon and the contractor corrects those areas they will be rechecked with a 10' straight edge or with Profilograph Simulation run. The verification method of the correction will be at the discretion of the project engineer. No additional areas will be required to be corrected after the agreed areas have been corrected. The contractor then will make their final run for pay.

# Chapter VI. Section 503 – Asphalt Concrete Equipment and Processes

This chapter describes the equipment and processes used in producing Asphalt Concrete mixture for a DOTD project under Standard Specifications, Section 501 (Thin Asphalt Concrete Applications), Section 502, (Asphalt Concrete Mixtures), and in conjunction with Section 503, (Asphalt Concrete Equipment and Processes).

This chapter shall be used along with Section 501, Section 502 and Section 503 of the Standard Specifications. This chapter also applies to subsections of Section 1002 (Asphalt Materials and Additives) and Section 1003 (Aggregates).

## A. Plant Certification

### 1. Initial Plant Certification

Plants furnishing asphalt concrete mixtures in accordance with Sections 501 and 502 shall be certified at least every two years pending inspection and approval by the DLE. The district laboratory in the district in which the plant is located will certify the plant. Material shall not be produced or accepted on any DOTD project from an asphalt plant that does not possess a valid certification. Certified plants will have a Plant Inspection Certification sticker placed in an obvious location in the plant control house.

Following is a list of steps required to certify a plant and on-site laboratory:

1. The plant shall be operational with approved materials on-site and be capable of producing mixtures that are correctly proportioned and mixed. The plant shall consistently produce specified materials in accordance with Sections 501 or 502.

2. In accordance with Subsection 503, the plant and laboratory equipment, meters, scales and measuring devices, and plant mixture-weighing device shall be tested, inspected and certified by the Weights and Measures Division of the LA Department of Agriculture and Forestry or by an independent scale service, licensed by Louisiana and approved by the certifying district laboratory engineer. These certifications shall be maintained in the Plant Certification File for access by district laboratory personnel. The service/technician will place a signed sticker in an obvious location in the plant control house. Scales shall be checked in a conventional manner using known weights of sufficient size to check the scale system in its upper ranges with a minimum number of loadings, to the satisfaction of the department

3. The producer shall notify the district laboratory that the plant is ready for certification.

4. The DLE will send qualified personnel to certify the plant using the DOTD Asphalt Concrete Plant Certification Report. This form documents the

inspection of materials, crushing apparatus, individual plant components, storage/surge silos, testing and laboratory. The district laboratory engineer must sign and date the form.

5. Upon satisfactory completion of the Asphalt Concrete Plant Certification Report, plant certification will be granted for a two-year period, provided the plant is maintained in accordance with the conditions under which certification was issued.

**NOTE:**

When a calibration service/technician located outside of Louisiana must be used to calibrate a scale or metering device, the service/technician shall be licensed by the state where the service/technician is located under standards similar to those required by Louisiana and approved by the DOTD Materials Engineer Administrator.

## 2. Random Conformance Inspections

The plant will be inspected randomly, a minimum of once a month, to conform to certification requirement by the ADI for the DLE. Upon completion of the conformance inspection the ADI will report findings to the DLE and Contractor. If deficiencies are identified, the Contractor will need to correct these deficiencies within the agreed upon timeframe with the DLE. Failure to correct these deficiencies may result in a suspension to continue to provide mix to department projects as determined by DLE.

During these inspections the ADI will be in charge of reviewing the following:

1. Inspect Plant Operations within Certification
2. Plant Equipment Inspection
3. Lab Equipment
4. Lab Technician’s Certifications
5. Observe Technician’s Test Procedures
6. Materials
7. Re-Certification Deadline
8. Testing Frequency Compliance

All these items will be documented in the report.

## 3. Re-Certification

Before the two-year certification period expires, the producer shall notify the district laboratory that the plant is ready for re-certification.

The producer shall also notify the DLE of any major change in the manufacturing process at the plant because a new certification inspection will be required. This would include the installation of a new dryer/drum, RAP system, baghouse, storage/surge system, proportioning system, crumb rubber system, chemical additive system (warm mix), or latex system.

### 4. Revoked Certification

If a plant fails to conform to DOTD standards under which certification was issued, the DLE will revoke the plant certification. The certifying DLE may also revoke plant certification when the mixture demonstrates continued non-conformance to specifications.

Once certification has been revoked the plant will be prohibited from supplying mix for any department project until all deficiencies have been corrected and certification is reinstated by the DLE.

### 5. Plant Laboratory Equipment and Documentation

The plant shall be equipped with a quality control/acceptance laboratory. The plant laboratory shall contain equipment to meet the requirements of the specifications and as referenced in applicable test procedures.

#### a) *Design Laboratory Equipment Requirements*

At the time of this printing, the following equipment is required, but not limited to:

- Constant Temperature Oven [100°F (38° C) to 400°F (204° C)] A 350°F (177° C) capability oven is for heating loose mix. It should be of adequate size to hold 3 gyratory molds. An oven of 125°F (52° C) capability is required for moisture content determination and for drying cores.
- Fume hood(s) -
- Specimen Ejector
- Shakers, splitters, scales
- Approved SHRP Gyratory Compactor, and extra molds (4 recommended).
- Maximum Specific Gravity ($G_{mm}$) apparatus, including vibrating table, pycnometer, vacuum pump and drier apparatus, and residual pressure manometer
- Bulk Specific Gravity ($G_{mb}$) apparatus, including balance, temperature controlled water bath equipped with overflow spigot
- Equipment to perform $G_{sb}$
- Saw, suitable for cutting pavement cores and gyratory specimens (wet saw preferred)
- Automated Ignition Furnace
- Freezer for TR 322, Tensile Strength Ratio
- Breaking heads for Lottman test

- Water baths, at 77° F (25° C) and at 140° F (60° C).
- Draindown test apparatus
- Computer and adequate connection for internet connectivity (for data tracking software and online reference manuals)
- Laboratory Equipment Manual which documents equipment calibrations
- Void content apparatus (FAA) and a Flat & Elongated (F&E) Gauge are required.
- Approved Loaded Wheel Tracker (LWT) System
- Semi Circular Bend (SCB)
- Other laboratory equipment used to perform Quality Control/Acceptance Testing

Additional equipment that may be required based on mix design submitted. The following is a list of equipment, but not limited to:

- DSR

The contractor shall supply all of this equipment. Also, the contractor shall provide sufficient six-inch diameter molds and auxiliary equipment necessary for the gyratory compactor and its calibration. A loading scoop (chute) for transferring material to gyratory molds is recommended to minimize segregation and temperature loss and help in attaining consistency.

All equipment supplied by the contractor/producer (including electronic scales) shall be maintained, serviced and calibrated in accordance with the manufacturers' recommendations and Subsection 503.02.2.

The DLE or their represenetive will inspect and approve all laboratory equipment supplied by the contractor/producer at the time of initial plant certification and during all subsequent inspections.

All laboratory equipment shall be calibrated and verified by the procedures in AASHTO R18, the appropriate test methods, and by the frequency directed in AASHTO R18.

The contractor shall maintain a Laboratory Equipment Manual containing all records for calibration of plant equipment. See the Preface and website for information and worksheets.

b) *Production Plant Laboratory Equipment Requirements*

At the time of this printing, the following equipment is required, but not limited to:

- Constant Temperature Oven [100°F (38° C) to 400°F (204° C)] A 350°F (177° C) capability oven is for heating loose mix. It should be of adequate size to hold 3 gyratory molds. An oven of 125°F (52° C) capability is required for moisture content determination and for drying cores.
- Fume hood(s)
- Specimen Ejector

- Shakers, splitters, scales
- Approved SHRP Gyratory Compactor, and extra molds (4 recommended).
- Maximum Specific Gravity ($G_{mm}$) apparatus, including vibrating table, pycnometer, vacuum pump and drier apparatus, and residual pressure manometer
- Bulk Specific Gravity ($G_{mb}$) apparatus, including balance, temperature controlled water bath equipped with overflow spigot
- Saw, suitable for cutting pavement cores (wet saw preferred)
- Automated Ignition Furnace
- Water baths, at 77° F (25° C) and at 140° F (60° C).
- Draindown test apparatus
- Computer and adequate connection for internet connectivity (for data tracking software and online reference manuals)
- Laboratory Equipment Manual which documents equipment calibrations
- Other laboratory equipment used to perform Quality Control/Acceptance Testing

## B. Scales and Meters Certification

In accordance with Subsection 503.02.2, every 90 days (or more frequently, if directed by the district laboratory engineer), the plant shall have its meters, scales and measuring devices tested, inspected and recertified by the Weights and Measures Division of the LA Department of Agriculture and Forestry or by an independent scale service approved by the certifying district laboratory engineer. The required DOTD Certification Report for Scales and Meters shall be completed and sent to the DLE each 90 days. One copy shall be retained at the plant in the Certification File.

There must be a calibration sticker on each scale and meter. If the DOTD ADI has reason to question the calibration of any scale or meter, the inspector will contact the DLE. The DLE has the authority to require the recalibration of scales or meters even though the ninety-day calibration sticker has not expired.  Meters must properly display flow rate and total amount of material and liquid dispensed.

## C. Roadway Equipment Approval

Primary roadway equipment shall be approved on a project by project basis. This equipment includes asphalt distributors, pavers, rollers, hauling, and MTV equipment. A DOTD representative will inspect and complete the Asphalt Concrete Paving Equipment Paving Approval Form.  This approval signifies that the equipment is in satisfactory condition and is capable of performing its function as related to proper paving practices and in accordance with department standards.  Final approval will be granted following an evaluation of the equipment's performance on the project.

For haul trucks, separate tractor/trailer- trucks require certification together as a unit so that an accurate total tare weight may be determined.  The DOTD number on separate tractor/trailers must match, showing that they were originally certified together.  A new trailer shall require a new certification. Prior to certification, a truck or tractor/trailer shall have its tare weight determined on a truck scale certified by the Weights and Measures Division of the Louisiana Department of Agriculture and Forestry. This tare weight shall be determined with the fuel tank at least three quarters full. The tare weight is used to calculate the maximum payload the truck or tractor/trailer is permitted to legally haul according to its axle size. DOTD Engineering Directives and Standards (EDSM) Number III.1.1.12 outlines the *Enforcement of Legal Load Requirements on Construction and Maintenance Construction Projects* (See website.). A copy of the DOTD truck (and trailer, if applicable) Weight Certification Tag is shown in.

**NOTE:**

The contractor will not be allowed to certify more than 3 tractor and trailer combinations.

Transport and roadway paving equipment shall perform to the satisfaction of the project engineer. If equipment fails to perform satisfactorily or is not maintained in acceptable condition the inspector is to notify the project engineer. If an equipment malfunction is detrimental to the project, the roadway inspector has the authority to require the removal of the equipment.

## D. Inspection of Plant and Roadway Equipment

The ADI and the Certified Paving Inspector are the official representatives of the department through the authority of the DLE and Project Engineer, respectively.

The concept of applying a payment adjustment to certain acceptance tests does not imply that the role of the DOTD Inspector is limited to performing or monitoring these tests. Increased dependence on contractor/producer quality control programs has extended the need for DOTD inspectors to be knowledgeable and vigilant concerning the design, production, transport, placement and compaction of hot-mix asphalt materials. It is intended that all requirements of the specifications shall be adhered to, not merely those to which payment adjustments are applied.

If problems arise in the production, transport or paving operations, it is the Inspector's responsibility to notify the contractor/producer's representatives that the product is not meeting department standards. The DOTD Inspector will tell the contractor/producer what is wrong, but **under no circumstances is the inspector to order a solution to the problem by word or action**. Correcting the problem so that the product meets all requirements of the specifications is the responsibility of the contractor/producer. If corrective actions are not made, the inspector is to notify the project engineer and DLE and make a subsequent investigation to ensure that corrective action has been taken. The inspector will document all actions, discussions with other department personnel and contractor/producer personnel, any other information relevant to the situation and will take measurements or samples, as necessary, to identify the problem.

When deficiencies occur in any area of the production, transport or paving processes, the contractor/producer must take immediate action to correct the problem. Failure to do so can result in the discontinuance of operations for DOTD projects. Quality control shall be accomplished by a program independent of, but correlated with, the department's acceptance testing and shall verify that all requirements of the JMF are being achieved, and that necessary adjustments provide specification compliance. It is the intent of the specifications that mixtures provided meet 100% for all production. Whenever the mixture produced falls into areas under which payment adjustment schedules must be applied, the contractor/producer shall make immediate adjustments or the DOTD Inspector will require the discontinuance of operations for DOTD projects.

### 1. Plant Inspection

The Department's ADI must continually observe the entire manufacturing process when at the plant. The inspector is to make a minimum of one monthly inspection of the plant to ensure that it is in conformance with the standards under which certification was granted. The inspector must be familiar with Section 503 of the *Standard Specifications*, Asphalt Concrete Equipment and Processes, and the certification standards for plants. It is also the inspector's responsibility to observe the contractor/producer's testing, monitor the results, and perform any sampling and testing operations assigned to department personnel. The plant equipment and operations are to be inspected continually during production to ensure that no malfunctions have occurred which will have a detrimental effect on the mixture.

The following headings indicate areas of the plant in which routine inspection is considered essential. These lists are not intended to be comprehensive or to exclude other areas from regular inspection. They are merely intended to serve as a guide to the inspector in the performance of this responsibility.

### 2. Plant Equipment

**Stockpiles and Handling -** Any new materials delivered to the plant are to be inspected, sampled, and tested in a timely manner so that production is not disrupted.

Aggregates must be handled in a manner that will not be detrimental to the final mixture.

Stockpiles shall be built without causing segregation. Segregation can be minimized if stockpiles are constructed in successive layers, not in a conical shape. Stockpiles shall be located on a clean, stable, well-drained surface to ensure uniform moisture content throughout the stockpile. The area in which the stockpiles are located shall be large enough for the stockpiles to be separated, so that no intermixing of materials will occur. Stockpiles shall not become contaminated with deleterious materials such as clay balls, leaves, sticks or non-specification aggregates.

**Material Proportioning** – All materials used, such as aggregates, asphalt cement, mineral filler, hydrated lime, fibers and RAP shall be proportioned by fully integrated measuring systems that maintain the required proportions in conformance with the approved mix design.

**Cold Bins** – Cold feed apparatus shall conform to Subsection 503.03.2 and shall be inspected routinely. Bins shall be of the proper size to accommodate loader bucket size and plant production. They shall also be of a configuration that will not contribute to segregation and be in good condition. There shall be no holes in any bin. The bin separating partitions shall not be worn or broken. If a partition is damaged to the point that this specification is not met, the contractor/producer shall replace the damaged part. Cold feed bins shall be loaded in a manner that will not contribute to segregation. Aggregates shall be dumped into the center of each bin. Bins shall be kept adequately filled with a relatively constant level of material with uniform moisture content.

Belt feeders shall be in good condition, not worn or broken. Gate openings and belt speeds shall be set to distribute the appropriate gradation for the job mix formula being produced. The gate openings and belt speeds shall be periodically inspected to ensure that they remain properly set. Aggregates shall flow uniformly onto the belt. Clogged gates, bridging or excessive moisture can cause non-uniform flow.

**Truck Loading** – The loading of trucks will be observed to ensure that loading techniques or discharge equipment is not contributing to mixture segregation. Equipment that drops a large amount of mixture at a time into the truck will tend to generate less segregation than compared to equipment that discharges a small flow/stream. The material dropped into the front and back should be placed as close as possible to the front and back of the bed to minimize segregation caused by the rolling of large aggregates. The intent of this truck loading procedure is to minimize the roll down of coarse aggregate at the front and back of the truck and to concentrate any roll down in the center of the load, where it will be more readily mixed with the mass of material during discharge into the paver or MTV. When equipment necessitates deviating from this procedure, the producer may modify this procedure as long as segregation does not occur.

Drum mix plants will be checked for satisfactory performance by inspecting the material exiting the drum mixer. It will be checked for temperature, coating [Ross Count, (DOTD TR 328), if questionable], moisture and segregation. If segregation is occurring during the mixing process, one side of the material coming out of the dryer/drum will usually be fine and the other coarse. Such segregation is often caused by improper drum operation.

Material produced at the beginning or termination of production periods shall be diverted from DOTD projects. During startup, the Contractor shall observe the mixture coming out of the diversion chute during these periods to determine that proper mixing and coating are being achieved before allowing the HMA materials to enter the surge or storage silos.

The surge or storage silos in use at all plants are components that must be carefully and routinely inspected. The batcher on the top of the silo must operate properly and at all times. The gates must close tightly so that material cannot dribble through. The storage silo or surge silo should maintain the proper cone shape of the material in storage to reduce the height of mix drop, thereby helping to prevent segregation.

On a monthly basis, when the plant is in production, the ADI will, as a part of continuous quality assurance efforts, inspect the plant and its individual components. Section 503 (Asphalt Concrete Equipment and Process) outlines requirements for the inspection of the following items:

- Asphalt cement tanks (storage and working)
- Anti-strip additive equipment
- Cold aggregate feeders (bins)
- Hydrated Lime/Mineral Filler equipment (if used)
- Screening systems
- Dryer/drums
- Thermometers (including thermocouples)
- Dust collection systems (baghouses)
- Asphalt Measuring Equipment
- Weigh hoppers (if used)
- Scales and printer systems
- Storage and Surge silos
- Mix Release agent dispenser systems

Not only shall proper functioning of these individual components be inspected, but their combined operation is to be continually monitored for proper quality assurance.

### 3. Inspection of Mixture at Plant

**Temperature of the HMA Mixture –** The temperature is to be checked a minimum of 1 truck per P-lot by the Contractor and reported in the DOTD tracking software. For each temperature determination, the temperature shall be checked in more than one location per truck.

**Segregation** – HMA mixtures that exhibit obvious segregation when loaded at the plant shall not be issued a haul ticket. The material shall not be transported to a DOTD project. If there is plant segregation the loading procedure, stockpile construction, cold feed bin operation, mixing process and surge/storage bin operations should immediately be inspected for proper function.

**Uniformity** – The HMA material should be uniform in appearance in all aspects from batch to batch and from one area of the truckload to another. There should be no lumps, areas of differing color, segregation or wet/dry areas. Inconsistent color throughout a truckload may also be the result of excessive dryer/drum flight wear, low or excessive asphalt cement content or inadequate drying/heating. If the mixture does not exhibit acceptable uniform color, the Contractor is to identify and correct the problem.

**Odor –** Burned or unusual odor may be indicative of oxidized asphalt cement.

**Asphalt Coating –** HMA material which exhibits obvious coating deficiencies shall not be transported to a DOTD project. If the Certified Technician suspects that the mixture is improperly coated, he/she will sample the deficient material and perform a Ross Count to determine if the material meets the DOTD requirements of 95% coating.

**Moisture** – Excess moisture in HMA materials may cause the mixture to appear to have excessive asphalt cement. Hence, the material will appear to be wet and shiny and slump in the truck. This is because, prior to moisture evaporation,, the saturated steam is acting like excess asphalt cement. If the Certified Inspector(s) suspects moisture problems, then the HMA material shall be analyzed for moisture content (DOTD TR 319). **The maximum moisture content allowed by specifications is 0.3%.**

### 4. Haul Ticket

All truckloads of HMA materials shall be accompanied by a properly completed haul ticket. Haul tickets show the exact quantity, by weight, of material in the haul truck. This quantity, in tons, is used to determine pay. No material shall be placed from a truck without a properly completed haul ticket.

The P-Lot number shall be indicated on each haul ticket. The P-Lot number may be either printed on the ticket via the printer system or written on the DOTD stamped form on the back of the ticket.

The Contractor shall keep a running total of production to ensure that all P-Lot are terminated at proper tonnage and that the succeeding P-Lot number is placed on the next haul ticket. Lot numbers will be assigned based on total tons of plant production for a JMF. Lot numbers will be sequential to plant production for DOTD without regard to delivery points, individual projects or mix types. Therefore, P-Lot numbers for an individual project could start at lot number 001 or at any lot number thereafter and will not necessarily be sequential on a project. P-Lot numbers will be unique for individual JMFs. The DOTD assigned JMF sequence number will be part of the P-Lot number.

Ex. 101-001 101 = DOTD JMF sequence number, 001 = the first P-Lot for the JMF. P-Lot numbers are sequential and should continue from project to project.

The Contractor shall also maintain a log of the distribution of hot-mix production for DOTD projects from a plant's operation. This log shall contain, as a minimum, the following data:

- Date
- State Project(s) mix shipped to
- DOTD JMF sequence number and P-Lot No. (ex. 101-001)
- Tons shipped
- Accumulated tons of JMF
- Remarks
- Initials (if written logs are maintained)
- AC Type

This log is to remain at the plant as a continuing record of plant production and distribution. It is to be maintained separately from all other department documentation.

5. Roadway Equipment

**Haul Trucks** – Trucks are to be routinely inspected to ensure they are clean and that there are no holes in the trailer beds. Materials shall not be allowed to build up in truck beds. Truck beds must be coated with an approved mix release agent, as needed. Neither diesel nor any other petroleum based product shall be used as a mix release agent. Each truck shall have an adequate cover and tie downs. The cover must be in good condition with no holes or tears and must cover the complete bed. Covers shall be used to protect the material from rain and excessive temperature loss. All haul trucks shall have silver weight certification stickers attached to the cab and the trailer unit. These two stickers must match to be valid. If the weight certification stickers are not valid, the haul truck shall be removed from the project.

**PAVERS** – The paver shall be operated at a consistent speed that will produce a smooth, uniformly textured pavement surface and create a continuous operation in conjunction with plant production and hauling capacity. Use a paver insert hopper in conjunction with the MTV with a minimum capacity of 5 tons. The hopper is to be kept reasonably full at all times; the slat conveyors should never be uncovered. Cold, segregated material in the hopper wings shall not be dumped into the paver. The paving inspector will check the sensitivity of the paver's electronic controls to ensure they are working properly.

If screed extensions are used, they must be heated and meet all screed requirements and produce the same quality surface as the screed. When auger extensions are required, they must extend to within one foot of the end of the screed. With approval, the use of an auger extension with screed extensions in excess of one foot on one side may be waived for transitions, taper sections and similar short sections or when hydraulically extended screeds, which trail the main screed assembly, are used, provided required density and surface texture are obtained.

**MTV –** The MTV shall comply with Section 503.14 of the Standard Specifications. If Lightweight MTV (503.14.1) and/or Windrow Paving (503.14.2) are used then a Thermal Profile System (503.14.3) will be required to be attached to the paver. The DOTD Inspector will check for thermal segregation of the mix. If thermal segregation is found, the operation should be discontinued and changes made to allow continuation of the laydown operation.

**Asphalt Distributor –** The Asphalt Distributor shall comply with Section 503.13 of the Standard Specifications. The inspector should check to ensure that the Distributor meets the requirements in section 503.13.1 and note this on the Asphalt Concrete Paving Equipment Project Approval form.

Within 12 months prior to use, calibrate the asphalt distributor in accordance with ASTM D 2995. Provide the ASTM calibration record to the project engineer prior to beginning work. The engineer may at any time require verification of calibration accuracy of the asphalt distributor in accordance with ASTM D 2995.

**ROLLERS** – It is critical to the life of an HMA pavement that it be properly compacted to develop the strength and proper aggregate interlock intended for the mixture.

Sufficient compactive energy should be applied as necessary for adequate design density. A properly compacted pavement will provide a smooth, sealed riding surface.

It is the Contractor's responsibility to establish a rolling pattern that will ensure optimum and consistent density. Almost every project or mixture type requires a varied rolling pattern. The ability of a mixture to be compacted will be affected by variables such as mixture temperature, aggregate gradation, type of aggregate and asphalt, ambient temperature, moisture content, and condition of the foundation on which the HMA is being placed and compacted.

Section 503.16 of the *Standard Specifications* states that all compaction equipment must be self-propelled and be capable of reversing without backlash. It is the contractor's responsibility to provide the number, type and size of rollers sufficient to compact the mixture to the specified density and surface smoothness. The contractor shall establish the number, type, size and rolling pattern on the first day of production for a particular mix design. Once established, the same protocol shall be maintained throughout production. If the pavement or mixture characteristics are changed during the project, the project engineer may require a revised protocol deemed appropriate for those changes. Compaction equipment shall be comply in accordance with Subsection 503.16.

Steel wheel rollers may be either vibratory or nonvibratory. The wheels shall be true to round and equipped with suitable scraper and watering devices. If used, **vibratory rollers shall be designed for HMA compaction and shall have separate controls for frequency, amplitude and forward speed.** Non-vibrating steel wheel rollers shall be operated with drive wheels toward the paver. Vibratory rollers shall not be used on the first lift of HMA placed over asphalt treated drainage blanket. When HMA is placed on newly constructed cement or lime stabilized or treated layers, vibratory rollers shall not be used for at least 7 days after such stabilization or treatment. Steel wheels shall be checked for flat spots.

Drawbar pull is defined as the horizontal force required to move the roller forward. The most efficient roller is that with the smallest drawbar pull. Rollers with large diameter drums have lower drawbar pull (rolling resistance), because they do not penetrate as far into the mix to develop a contact area as a roller with smaller diameter drums.

All tires for pneumatic tire rollers shall have smooth tread, shall be the same size and ply rating, and shall be inflated to a uniform pressure not varying more than ±5 psi between tires. Wheels shall not wobble and shall be aligned so that tires of the other axle cover gaps between tires on one axle. Tires shall be equipped with scrapers to prevent adhesion to the HMA material. The pneumatic tire roller shall be kept 6 inches from unsupported edges of the paving strip; however, when an adjacent paving strip is down, the roller shall overlap the adjacent paving strip approximately 6 inches. All scrapers and watering systems shall be in good condition and functioning properly.

Rollers shall be operated at uniform speeds that will coordinate with paver speed and within the frequency setting so as to allow for proper drum impacts per linear foot. The more quickly a roller passes over a particular point in the new HMA surface, the less time the weight of the roller rests on that point. This in turn means that less compactive effort is applied to the mixture. As roller speed increases, the amount of density gain achieved with each roller pass decreases. The roller speed selected is dependent on a combination of the following factors:

- Paver speed
- Layer thickness
- Position of the roller in the roller train.

Typically static steel wheel rollers can operate at speeds of 2 to 5 miles per hour; pneumatic tire rollers typically run 2 to 7 miles per hour; a vibratory roller can operate at speeds of 2 to 3 ½ miles per hour. Roller speed is also governed by the lateral displacement or tenderness of the HMA mix. If the mixture moves excessively under the roller, the speed of the compaction equipment should be reduced. As discussed earlier, roller speed affects the impact spacing for vibratory rollers. This spacing is important for controlling the amount of dynamic compaction energy applied to the pavement, as well as for obtaining the proper surface smoothness. In general, at least 10 to 12 impacts per foot are needed to obtain adequate density and layer smoothness.

Rollers are not to reverse in the same location on subsequent passes. Reversal points of continuous passes should be skewed at an angle of approximately 45 degrees across the mat. Rollers should cross their reversal points when moving across the mat surface in order to smooth any dips or bumps caused by changing direction. When a vibratory roller is used for breakdown rolling, the vibrators must be turned off to compact joints or whenever the roller stops or changes direction.

The paving inspector will inspect the mat during compaction after the rollers have passed. If the mat tears, blisters, shoves, leaves indelible marks or displaces in any way beneath the roller, the paving inspector will require the contractor to adjust the operation so that the mat is not damaged. Deficiencies shall be corrected.

Rollers for SMA shall be steel wheel weighing a minimum of 10 tons operated at high frequency and low amplitude. SMA Mix shall be rolled immediately after placement. The mastic shall not be allowed to migrate to the surface. Rolling shall continue until all roller marks are eliminated and minimum density is obtained, but not after the mat has cooled below 220° F. Traffic will not be allowed on the newly compacted SMA until the mat has cooled to 140° F or lower.

**Tender Zone** – A mid-temperature *tender zone* has been identified for some Superpave mixes. The tender zone has been identified in temperature ranges of approximately 200° F to 240° F. The mixture can be satisfactorily compacted above this range or below this range, but the mixture is tender within the temperature range and cannot be adequately compacted. This is not true for all mixtures, but it has been observed for some Superpave designed mixtures.

When a mixture is tender within the mid-temperature range, the preferred compaction method is to obtain density prior to cooling to the point of the tender zone. This may require an additional breakdown roller or other changes in rolling techniques, but obtaining density prior to reaching the tender zone is preferable. In some cases, the mixture temperature may be increased slightly to provide more compaction time. However, excessive temperatures will magnify the problem. Another alternative is to use a vibratory steel wheel breakdown roller above the tender zone, followed by a rubber tire roller, which can be operated in the tender zone. The finish roller should be used after the mixture has cooled below the tender zone. This second method may not be satisfactory if the rubber tire roller picks up excessively.

Another possibility is to breakdown with a steel wheel roller above the tender zone, then complete the rolling process after the HMA has cooled to below the tender zone. This has been used on a number of projects, but problems may occur due to differential cooling of the mixture and due to excessive aggregate breakdown when rolling in the vibratory mode after the mixture has cooled to below 200° F. Therefore, vibratory rolling should not be used below 200° F.

If the tenderness problem yields a pavement with poor in-place density, or if the paving train length is excessively long due to the time required for the mixture to cool, adjustments to the mixture design must be made to eliminate, or at least reduce, the temperature tenderness zone. It is important that the paving crew working at the laydown site communicate with the plant personnel.

**Surface Preparation** – The requirement to use tack coat, prime coat or curing membrane depends on the type of surface material upon which it is being placed. The different types of Asphalt materials, along with their applicable sections in the *Standard Specifications,* are as follows:

1. Tack Coat - (Section 504) is applied to existing hot-mix asphalt, Asphalt surface treatment, or Portland cement concrete pavement surface. The distributor used to apply the tack coat shall be certified.

2. Prime Coat – (Section 505), is applied to untreated base course such as crushed aggregate, stone and concrete base courses. The distributor that is used to apply the prime coat shall be certified.

3. Curing Membrane – (Section 506), is applied to treated base courses such as on the surface of cement or lime-treated/stabilized materials. The distributor used to apply the curing membrane does not have to be certified, but shall be approved by the Engineer.

# Chapter VII. Section 504 – Asphalt Tack Coats

Record the temperature of the tack truck for information. Tack coat rate and quantity as measured by the calibrated tack coat distributer will be recorded and used for verification. Shipments of tack coat emulsion must be accompanied with a Certificate of Delivery, collected by the contractor and delivered to the DOTD inspector.

If the tack coat distributer has to leave the project, the operator shall inform the DOTD inspector. The DOTD inspector will take a gallons reading of the distributor for verification calculations. If the distributor has to refill, the inspector will take a reading upon the return of the distributor.

Within 12 months prior to use, calibrate the asphalt distributor in accordance with ASTM D 2995. Provide the ASTM calibration record to the project engineer prior to beginning work. The engineer may at any time require verification of calibration accuracy of the asphalt distributor in accordance with ASTM D 2995.

Measurement will be by the in place gallon per square yard. The DOTD Certified Paving Inspector will compute the square yards covered and gallons placed to calculate application rates.

Tack coat will not be paid for separately but will be incidental to asphalt mixtures.

When questionable tack coat will be sampled in plastic one gallon containers as stated in the sampling plan or MSM.

Application Rate Calculation:

Application rate is based on gallons per square yard.

$$\frac{\text{gal}}{\text{yd}^2} = \text{application } \textit{rate}$$

$yd^2$ = area covered = length in feet x width in feet ÷ 9

station 10+00 to 56+80 = 4680’ length

Paving width 12.5’

4680 x 12.5 = 58500’ ÷ 9 = 6500 $yd^2$

260 gallons of tack used as measured from Tack Distributor

$$\frac{260\ \text{gal}}{6500\ \text{yd}^2} = 0.04\ \text{gal/yd}^2 \text{ application rate}$$

APPENDIX (DOTD will calculate pay in SMM or Excel)

- Table of Quality Index Value
- PWL Pay Table.

# APPENDIX

# APPENDIX

## Quality Index Values and Pay Table

**Quality Index Values for Estimating Percent Within Limits**

| PWL | n = 3 | n = 4 | n = 5 - 6 | n = 7 - 9 | n = 10 - 12 | n = 13 - 15 |
|---|---|---|---|---|---|---|
| 99 | 1.16 | 1.47 | 1.68 | 1.89 | 2.04 | 2.14 |
| 98 | 1.15 | 1.44 | 1.61 | 1.77 | 1.86 | 1.93 |
| 97 | 1.15 | 1.41 | 1.55 | 1.67 | 1.74 | 1.80 |
| 96 | 1.15 | 1.38 | 1.49 | 1.59 | 1.64 | 1.69 |
| 95 | 1.14 | 1.35 | 1.45 | 1.52 | 1.56 | 1.59 |
| 94 | 1.13 | 1.32 | 1.40 | 1.46 | 1.49 | 1.51 |
| 93 | 1.12 | 1.29 | 1.36 | 1.40 | 1.43 | 1.44 |
| 92 | 1.11 | 1.26 | 1.31 | 1.35 | 1.37 | 1.38 |
| 91 | 1.10 | 1.23 | 1.27 | 1.30 | 1.32 | 1.32 |
| 90 | 1.09 | 1.20 | 1.23 | 1.25 | 1.26 | 1.27 |
| 89 | 1.08 | 1.17 | 1.20 | 1.21 | 1.21 | 1.22 |
| 88 | 1.07 | 1.14 | 1.16 | 1.17 | 1.17 | 1.17 |
| 87 | 1.06 | 1.11 | 1.12 | 1.12 | 1.13 | 1.13 |
| 86 | 1.05 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 |
| 85 | 1.03 | 1.05 | 1.05 | 1.05 | 1.04 | 1.04 |
| 84 | 1.02 | 1.02 | 1.02 | 1.01 | 1.00 | 1.00 |
| 83 | 1.00 | 0.99 | 0.98 | 0.97 | 0.96 | 0.96 |
| 82 | 0.98 | 0.96 | 0.95 | 0.94 | 0.93 | 0.92 |
| 81 | 0.96 | 0.93 | 0.92 | 0.90 | 0.89 | 0.89 |
| 80 | 0.94 | 0.90 | 0.88 | 0.87 | 0.85 | 0.85 |
| 79 | 0.92 | 0.87 | 0.85 | 0.83 | 0.82 | 0.82 |
| 78 | 0.89 | 0.84 | 0.82 | 0.80 | 0.79 | 0.78 |
| 77 | 0.87 | 0.81 | 0.79 | 0.77 | 0.76 | 0.75 |
| 76 | 0.84 | 0.78 | 0.76 | 0.74 | 0.72 | 0.72 |
| 75 | 0.82 | 0.75 | 0.73 | 0.71 | 0.69 | 0.69 |
| 74 | 0.79 | 0.72 | 0.70 | 0.67 | 0.66 | 0.66 |
| 73 | 0.77 | 0.69 | 0.67 | 0.64 | 0.63 | 0.62 |
| 72 | 0.74 | 0.66 | 0.64 | 0.61 | 0.60 | 0.59 |
| 71 | 0.71 | 0.63 | 0.60 | 0.58 | 0.57 | 0.56 |
| 70 | 0.68 | 0.60 | 0.58 | 0.55 | 0.54 | 0.54 |
| 69 | 0.65 | 0.57 | 0.55 | 0.53 | 0.51 | 0.51 |
| 68 | 0.62 | 0.54 | 0.52 | 0.50 | 0.48 | 0.48 |
| 67 | 0.59 | 0.51 | 0.49 | 0.47 | 0.46 | 0.45 |
| 66 | 0.56 | 0.48 | 0.46 | 0.44 | 0.43 | 0.42 |
| 65 | 0.53 | 0.45 | 0.43 | 0.41 | 0.40 | 0.40 |
| 64 | 0.49 | 0.42 | 0.40 | 0.38 | 0.37 | 0.37 |
| 63 | 0.46 | 0.39 | 0.37 | 0.35 | 0.35 | 0.34 |
| 62 | 0.43 | 0.36 | 0.34 | 0.33 | 0.32 | 0.31 |
| 61 | 0.39 | 0.33 | 0.31 | 0.30 | 0.30 | 0.29 |
| 60 | 0.36 | 0.30 | 0.28 | 0.27 | 0.26 | 0.26 |
| 59 | 0.32 | 0.27 | 0.25 | 0.24 | 0.24 | 0.23 |
| 58 | 0.29 | 0.24 | 0.23 | 0.21 | 0.21 | 0.21 |
| 57 | 0.25 | 0.21 | 0.20 | 0.19 | 0.18 | 0.18 |
| 56 | 0.22 | 0.18 | 0.17 | 0.16 | 0.16 | 0.15 |
| 55 | 0.18 | 0.15 | 0.14 | 0.13 | 0.13 | 0.13 |
| 54 | 0.14 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 |
| 53 | 0.11 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 |
| 52 | 0.07 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 |
| 51 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Note 1: For negative values of $Q_u$ or $Q_L$. $PWL_U$ or $PWL_L$ is equal to 100 minus the tabular $PWL_U$ or $PWL_L$.
Note 2: If the value of $Q_U$ or $Q_L$ does not correspond exactly to a value in the table, use the next higher value.

| Table A2 | Percent Payment - % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Estimated PWL** | **n = 3** | **n=4** | **n = 5** | **n = 6** | **n = 7** | **n = 8 to 9** | **n = 10 to 12** | **N = 13** | **n =14 to 17** | **n = 18 and greater** |
| 100 to 81 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 80 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 |
| 79 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 98 |
| 78 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 99 | 98 |
| 77 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 98 | 98 | 97 |
| 76 | 100 | 100 | 100 | 100 | 100 | 99 | 99 | 98 | 97 | 96 |
| 75 | 100 | 100 | 100 | 100 | 100 | 99 | 98 | 97 | 97 | 95 |
| 74 | 100 | 100 | 100 | 100 | 100 | 98 | 98 | 96 | 96 | 94 |
| 73 | 100 | 100 | 100 | 100 | 99 | 98 | 97 | 96 | 95 | 93 |
| 72 | 100 | 100 | 100 | 99 | 99 | 97 | 97 | 95 | 94 | 92 |
| 71 | 100 | 100 | 100 | 99 | 98 | 97 | 96 | 94 | 93 | 92 |
| 70 | 100 | 100 | 99 | 98 | 98 | 96 | 96 | 94 | 93 | 91 |
| 69 | 100 | 100 | 98 | 98 | 97 | 95 | 95 | 93 | 92 | 90 |
| 68 | 100 | 100 | 98 | 97 | 96 | 94 | 94 | 92 | 91 | 89 |
| 67 | 100 | 100 | 97 | 96 | 96 | 94 | 94 | 91 | 90 | 88 |
| 66 | 100 | 99 | 97 | 96 | 95 | 93 | 93 | 90 | 89 | 87 |
| 65 | 100 | 99 | 96 | 95 | 94 | 92 | 92 | 90 | 88 | 86 |
| 64 | 99 | 98 | 96 | 94 | 94 | 92 | 91 | 89 | 88 | 85 |
| 63 | 99 | 98 | 95 | 94 | 93 | 91 | 90 | 88 | 87 | 84 |
| 62 | 99 | 97 | 95 | 93 | 92 | 90 | 89 | 87 | 86 | 83 |
| 61 | 98 | 96 | 94 | 92 | 91 | 89 | 89 | 86 | 85 | 82 |
| 60 | 98 | 95 | 94 | 92 | 91 | 89 | 88 | 85 | 84 | 81 |
| 59 | 97 | 95 | 93 | 91 | 90 | 88 | 87 | 84 | 83 | 80 |
| 58 | 97 | 94 | 92 | 90 | 89 | 87 | 86 | 83 | 82 | 79 |
| 57 | 96 | 93 | 91 | 89 | 88 | 86 | 85 | 82 | 81 | 78 |
| 56 | 95 | 92 | 90 | 89 | 87 | 85 | 84 | 81 | 80 | 77 |
| 55 | 95 | 92 | 90 | 88 | 86 | 84 | 83 | 79 | 79 | 76 |
| 54 | 94 | 91 | 89 | 87 | 85 | 83 | 82 | 78 | 77 | 75 |
| 53 | 93 | 90 | 88 | 86 | 85 | 82 | 80 | 77 | 76 | 74 |
| 52 | 92 | 89 | 87 | 85 | 84 | 81 | 79 | 76 | 75 | 72 |
| 51 | 91 | 88 | 85 | 84 | 83 | 80 | 78 | 74 | 74 | 71 |
| 50 | 90 | 88 | 84 | 83 | 82 | 79 | 77 | 74 | 73 | 70 |
| 49 | 90 | 87 | 83 | 82 | 81 | 77 | 76 | 72 | 71 | 69 |
| 48 | 89 | 86 | 82 | 81 | 80 | 76 | 74 | 71 | 70 | 67 |
| 47 | 88 | 85 | 81 | 80 | 79 | 75 | 73 | 70 | 68 | 66 |

# PART 3 – APPENDIX

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 46 | 87 | 84 | 80 | 79 | 77 | 74 | 72 | 68 | 67 | 64 |
| 45 | 86 | 83 | 79 | 78 | 76 | 73 | 71 | 67 | 66 | 63 |
| 44 | 85 | 82 | 78 | 77 | 75 | 71 | 69 | 65 | 64 | 62 |
| 43 | 85 | 81 | 77 | 76 | 74 | 70 | 68 | 64 | 63 | 60 |
| 42 | 84 | 80 | 76 | 75 | 73 | 69 | 67 | 63 | 62 | 59 |
| 41 | 83 | 79 | 75 | 73 | 71 | 68 | 65 | 62 | 60 | 58 |
| 40 | 82 | 77 | 74 | 72 | 70 | 66 | 64 | 61 | 59 | 57 |
| 39 | 81 | 76 | 72 | 71 | 69 | 65 | 63 | 59 | 57 | 55 |
| 38 | 80 | 75 | 71 | 70 | 67 | 63 | 61 | 58 | 56 | 54 |
| 37 | 79 | 74 | 70 | 68 | 66 | 62 | 60 | 56 | 55 | 52 |
| 36 | 78 | 73 | 68 | 67 | 65 | 61 | 58 | 55 | 53 | 51 |
| 35 | 77 | 72 | 67 | 66 | 63 | 60 | 57 | 53 | 52 | 50 |
| 34 | 76 | 71 | 66 | 65 | 62 | 58 | 55 | 52 | 50 | |
| 33 | 75 | 70 | 65 | 63 | 61 | 57 | 54 | 50 | | |
| 32 | 74 | 69 | 63 | 61 | 60 | 55 | 52 | | | |
| 31 | 73 | 67 | 62 | 60 | 59 | 54 | 51 | | | |
| 30 | 72 | 66 | 61 | 58 | 57 | 52 | 50 | | | |
| 29 | 71 | 65 | 59 | 57 | 56 | 51 | | | | |
| 28 | 70 | 64 | 58 | 55 | 54 | 50 | | | | |
| 27 | 69 | 62 | 57 | 54 | 53 | | | | | |
| 26 | 68 | 61 | 55 | 52 | 52 | | | | | |
| 25 | 67 | 60 | 52 | 51 | 50 | | | | | |
| 24 | 66 | 59 | 50 | 50 | | | | | | |
| 23 | 64 | 58 | | | | | | | | |
| 22 | 63 | 56 | | **50 Percent or Remove** | | | | | | |
| 21 | 62 | 54 | | | | | | | | |
| 20 | 61 | 53 | | | | | | | | |
| 19 | 60 | 53 | | | | | | | | |
| 18 | 59 | 52 | | | | | | | | |
| 17 | 58 | 50 | | | | | | | | |
| 16 | 57 | | | | | | | | | |
| 15 | 56 | | | | | | | | | |
| 14 | 54 | | | | | | | | | |
| 13 | 53 | | | | | | | | | |
| 12 | 52 | | | | | | | | | |
| 11 | 51 | | | | | | | | | |
| 10 | 50 | | | | | | | | | |

## Generating and Using Random Numbers for Sampling Purposes

Generating random numbers for determining sampling will be covered in this section. This section is how to generate the number(s). Applying the number will be addressed in another section.

The practice of riding a project and just picking a spot to choose a sample location may seem random, but statistical analysis of this has proven that a pattern emerges. There are multiple ways to utilize random numbers. One way is the use of random number tables covered here. Statistical analysis used in this specification necessitates the use of random numbers that are just that, random.

The following tables have groups of numbers that are 10 across and 5 down. This grouping will be used to generate random numbers.

The inspector can generate numbers on a per lot basis or calculate the number of samples for a project and generate all the numbers for a project. Whichever method is started should be used for the whole project.

One roadway lot is 37,500’ in length composed of five (5) sublots 7500’ in length. Each sublot is divided into three (3) 2500’ sections.

Each 2500’ section will have an acceptance core taken for a total of three (3) per sublot. Each 7500’ sublot will have one (1) verification core and one (1) resolution core taken. This is 5 cores per sublot and 25 cores per lot.

25 total cores per lot

15 acceptance cores – 3 per sublot x 5 sublots
5 verification cores – 1 per sublot x 5 sublots
5 resolution cores – 1 per sublot x 5 sublots

25 random numbers for longitudinal distance and 25 random numbers for transverse distance for a total of 50 random numbers per lot are required.

The over and down method will be used to generate random numbers in this example. There are eight pages with seven groups of numbers per page.

The inspector can use down and then across or across and down. The selection can start left to right or right to left and then up or down depending on the starting point. The limitations are 10 horizontally and five vertically. Choose a pattern and use that pattern until all numbers are chosen or all sections are used. If more numbers are needed, pick another pattern and proceed until enough numbers are generated.

On the first page the pattern will be 3 down (vertical) and 7 across (horizontal). In each group of 50 numbers go down 3 rows and across 7 columns. Going down the first page, the 7 numbers generated are: 0.133, 0.954, 0.371, 0.393, 0.825, 0.416, and 0.608. The inspector will use this pattern through the eight pages below.

# PART 3 – APPENDIX

Once all the pages and groups are utilized another pattern will be used to generate numbers if more are need.

This pattern will be 3 across and 5 down.  56 numbers will be generated for later use.
The following numbers are generated from the eight pages of random numbers.

1$^{st}$ page:
0.034, 0.802, 0.474, 0.652, 0.211, 0.203, and 0.522.

2$^{nd}$ page:
0.649, 0.398, 0.229, 0.605, 0.811, 0.094, and 0.690

3$^{rd}$ page:
0.844, 0.701, 0.413, 0.996, 0.994, 0.810, and 0.231

4$^{th}$ page:
0.455, 0.606, 0.751, 0.658, 0.360, 0.814, and 0.073

5$^{th}$ page:
0.138, 0.573, 0.741, 0.705, 0.170, 0.792, and 0.534

6$^{th}$ page:
0.019, 0.656, 0.425, 0.031, 0.525, 0.874, and 0.099

7$^{th}$ page:
0.037, 0.185, 0.074, 0.786, 0.240, 0.355, and 0.703

8$^{th}$ page:
0.555, 0.746, 0.352, 0.251, 0.955, 0.234, and 0.645

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0.002 | 0.876 | 0.374 | 0.746 | 0.844 | 0.959 | 0.730 | 0.539 | 0.838 | 0.996 |
| 0.156 | 0.864 | 0.413 | 0.533 | 0.013 | 0.131 | 0.365 | 0.614 | 0.371 | 0.038 |
| 0.382 | 0.335 | 0.952 | 0.861 | 0.792 | 0.728 | 0.133 | 0.582 | 0.822 | 0.096 |
| 0.533 | 0.243 | 0.151 | 0.492 | 0.221 | 0.446 | 0.034 | 0.473 | 0.079 | 0.404 |
| 0.775 | 0.794 | 0.334 | 0.445 | 0.840 | 0.199 | 0.820 | 0.379 | 0.386 | 0.965 |
| 0.967 | 0.629 | 0.485 | 0.350 | 0.080 | 0.540 | 0.826 | 0.610 | 0.916 | 0.767 |
| 0.180 | 0.738 | 0.099 | 0.147 | 0.401 | 0.568 | 0.409 | 0.964 | 0.256 | 0.432 |
| 0.467 | 0.019 | 0.853 | 0.988 | 0.856 | 0.396 | 0.954 | 0.404 | 0.198 | 0.344 |
| 0.960 | 0.541 | 0.232 | 0.176 | 0.833 | 0.296 | 0.416 | 0.593 | 0.757 | 0.753 |
| 0.079 | 0.338 | 0.802 | 0.315 | 0.673 | 0.582 | 0.383 | 0.455 | 0.133 | 0.958 |
| 0.787 | 0.254 | 0.893 | 0.640 | 0.558 | 0.375 | 0.582 | 0.383 | 0.011 | 0.636 |
| 0.935 | 0.914 | 0.673 | 0.835 | 0.942 | 0.601 | 0.906 | 0.981 | 0.784 | 0.791 |
| 0.521 | 0.591 | 0.561 | 0.727 | 0.646 | 0.206 | 0.371 | 0.454 | 0.638 | 0.786 |
| 0.749 | 0.616 | 0.312 | 0.138 | 0.012 | 0.553 | 0.280 | 0.032 | 0.532 | 0.601 |
| 0.671 | 0.163 | 0.474 | 0.008 | 0.018 | 0.618 | 0.029 | 0.359 | 0.592 | 0.996 |
| 0.668 | 0.935 | 0.963 | 0.844 | 0.459 | 0.895 | 0.075 | 0.570 | 0.964 | 0.696 |
| 0.610 | 0.473 | 0.766 | 0.658 | 0.919 | 0.063 | 0.134 | 0.075 | 0.316 | 0.318 |
| 0.878 | 0.780 | 1.000 | 0.037 | 0.916 | 0.578 | 0.393 | 0.945 | 0.580 | 0.436 |
| 0.183 | 0.709 | 0.207 | 0.860 | 0.832 | 0.510 | 0.024 | 0.336 | 0.860 | 0.348 |
| 0.881 | 0.276 | 0.652 | 0.711 | 0.851 | 0.336 | 0.107 | 0.790 | 0.226 | 0.555 |
| 0.871 | 0.872 | 0.951 | 0.177 | 0.471 | 0.087 | 0.016 | 0.604 | 0.104 | 0.151 |
| 0.841 | 0.348 | 0.379 | 0.273 | 0.196 | 0.428 | 0.786 | 0.871 | 0.664 | 0.075 |
| 0.175 | 0.261 | 0.205 | 0.189 | 0.022 | 0.976 | 0.825 | 0.433 | 0.776 | 0.862 |
| 0.912 | 0.374 | 0.053 | 0.616 | 0.238 | 0.584 | 0.963 | 0.927 | 0.186 | 0.099 |
| 0.361 | 0.852 | 0.211 | 0.144 | 0.286 | 0.621 | 0.086 | 0.537 | 0.388 | 0.487 |
| 0.946 | 0.667 | 0.603 | 0.813 | 0.677 | 0.465 | 0.883 | 0.025 | 0.668 | 0.260 |
| 0.237 | 0.601 | 0.471 | 0.942 | 0.878 | 0.753 | 0.382 | 0.321 | 0.762 | 0.950 |
| 0.496 | 0.108 | 0.282 | 0.946 | 0.248 | 0.403 | 0.416 | 0.466 | 0.985 | 0.113 |
| 0.105 | 0.202 | 0.589 | 0.200 | 0.133 | 0.289 | 0.693 | 0.164 | 0.307 | 0.897 |
| 0.515 | 0.665 | 0.203 | 0.113 | 0.839 | 0.703 | 0.269 | 0.765 | 0.181 | 0.242 |
| 0.559 | 0.332 | 0.670 | 0.707 | 0.890 | 0.612 | 0.665 | 0.235 | 0.687 | 0.304 |
| 0.657 | 0.114 | 0.314 | 0.141 | 0.471 | 0.293 | 0.160 | 0.753 | 0.307 | 0.376 |
| 0.270 | 0.910 | 0.657 | 0.023 | 0.797 | 0.284 | 0.608 | 0.130 | 0.053 | 0.419 |
| 0.592 | 0.730 | 0.453 | 0.028 | 0.089 | 0.001 | 0.117 | 0.311 | 0.331 | 0.282 |
| 0.424 | 0.412 | 0.522 | 0.531 | 0.295 | 0.708 | 0.625 | 0.093 | 0.484 | 0.054 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0.229 | 0.224 | 0.656 | 0.666 | 0.541 | 0.241 | 0.546 | 0.781 | 0.026 | 0.728 |
| 0.967 | 0.759 | 0.724 | 0.702 | 0.947 | 0.777 | 0.791 | 0.129 | 0.796 | 0.782 |
| 0.272 | 0.718 | 0.356 | 0.847 | 0.657 | 0.383 | 0.238 | 0.590 | 0.241 | 0.284 |
| 0.313 | 0.818 | 0.822 | 0.862 | 0.253 | 0.047 | 0.772 | 0.758 | 0.384 | 0.052 |
| 0.997 | 0.034 | 0.649 | 0.113 | 0.847 | 0.602 | 0.952 | 0.097 | 0.470 | 0.260 |
| | | | | | | | | | |
| 0.672 | 0.051 | 0.670 | 0.247 | 0.622 | 0.449 | 0.794 | 0.722 | 0.235 | 0.756 |
| 0.665 | 0.076 | 0.260 | 0.456 | 0.110 | 0.474 | 0.758 | 0.216 | 0.108 | 0.544 |
| 0.651 | 0.328 | 0.084 | 0.615 | 0.648 | 0.090 | 0.385 | 0.410 | 0.784 | 0.288 |
| 0.474 | 0.594 | 0.393 | 0.419 | 0.862 | 0.104 | 0.764 | 0.838 | 0.322 | 0.633 |
| 0.286 | 0.455 | 0.398 | 0.214 | 0.346 | 0.158 | 0.770 | 0.276 | 0.771 | 0.618 |
| | | | | | | | | | |
| 0.468 | 0.100 | 0.093 | 0.618 | 0.502 | 0.071 | 0.416 | 0.580 | 0.917 | 0.633 |
| 0.167 | 0.431 | 0.810 | 0.364 | 0.514 | 0.473 | 0.344 | 0.056 | 0.732 | 0.416 |
| 0.286 | 0.229 | 0.299 | 0.216 | 0.101 | 0.971 | 0.996 | 0.896 | 0.136 | 0.516 |
| 0.801 | 0.978 | 0.922 | 0.460 | 0.863 | 0.716 | 0.125 | 0.031 | 0.315 | 0.754 |
| 0.181 | 0.314 | 0.229 | 0.389 | 0.141 | 0.831 | 0.495 | 0.079 | 0.766 | 0.401 |
| | | | | | | | | | |
| 0.882 | 0.365 | 0.388 | 0.656 | 0.086 | 0.853 | 0.586 | 0.155 | 0.042 | 0.423 |
| 0.199 | 0.472 | 0.263 | 0.304 | 0.700 | 0.186 | 0.520 | 0.194 | 0.483 | 0.157 |
| 0.608 | 0.065 | 0.069 | 0.022 | 0.506 | 0.806 | 0.785 | 0.291 | 0.705 | 0.385 |
| 0.934 | 0.969 | 0.975 | 0.649 | 0.985 | 0.091 | 0.367 | 0.458 | 0.826 | 0.101 |
| 0.723 | 0.274 | 0.605 | 0.455 | 0.477 | 0.884 | 0.187 | 0.373 | 0.029 | 0.409 |
| | | | | | | | | | |
| 0.760 | 0.141 | 0.469 | 0.245 | 0.629 | 0.861 | 0.940 | 0.107 | 0.717 | 0.069 |
| 0.417 | 0.819 | 0.813 | 0.120 | 0.179 | 0.014 | 0.091 | 0.743 | 0.765 | 0.405 |
| 0.947 | 0.678 | 0.683 | 0.764 | 0.658 | 0.804 | 0.670 | 0.287 | 0.924 | 0.648 |
| 0.761 | 0.494 | 0.800 | 0.708 | 0.975 | 0.310 | 0.069 | 0.464 | 0.878 | 0.498 |
| 0.569 | 0.521 | 0.811 | 0.092 | 0.520 | 0.746 | 0.070 | 0.987 | 0.377 | 0.850 |
| | | | | | | | | | |
| 0.813 | 0.350 | 0.233 | 0.287 | 0.975 | 0.990 | 0.317 | 0.893 | 0.974 | 0.365 |
| 0.609 | 0.169 | 0.493 | 0.369 | 0.101 | 0.611 | 0.112 | 0.557 | 0.749 | 0.998 |
| 0.075 | 0.967 | 0.626 | 0.035 | 0.973 | 0.195 | 0.333 | 0.270 | 0.628 | 0.876 |
| 0.168 | 0.684 | 0.949 | 0.230 | 0.123 | 0.858 | 0.055 | 0.831 | 0.197 | 0.125 |
| 0.429 | 0.249 | 0.094 | 0.623 | 0.410 | 0.731 | 0.817 | 0.639 | 0.771 | 0.561 |
| | | | | | | | | | |
| 0.186 | 0.158 | 0.691 | 0.282 | 0.834 | 0.030 | 0.896 | 0.401 | 0.682 | 0.647 |
| 0.240 | 0.768 | 0.449 | 0.547 | 0.517 | 0.262 | 0.214 | 0.852 | 0.786 | 0.945 |
| 0.570 | 0.934 | 0.982 | 0.353 | 0.392 | 0.231 | 0.102 | 0.059 | 0.758 | 0.608 |
| 0.747 | 0.183 | 0.056 | 0.173 | 0.292 | 0.994 | 0.791 | 0.958 | 0.478 | 0.264 |
| 0.156 | 0.362 | 0.698 | 0.536 | 0.856 | 0.772 | 0.766 | 0.946 | 0.257 | 0.264 |

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|---|---|---|---|---|---|---|---|---|---|
| 0.438 | 0.774 | 0.364 | 0.788 | 0.482 | 0.372 | 0.666 | 0.745 | 0.565 | 0.616 |
| 0.393 | 0.367 | 0.746 | 0.562 | 0.187 | 0.801 | 0.852 | 0.433 | 0.755 | 0.299 |
| 0.524 | 0.619 | 0.499 | 0.432 | 0.203 | 0.830 | 0.686 | 0.723 | 0.854 | 0.062 |
| 0.162 | 0.619 | 0.688 | 0.540 | 0.163 | 0.182 | 0.689 | 0.280 | 0.241 | 0.445 |
| 0.201 | 0.443 | 0.844 | 0.797 | 0.376 | 0.119 | 0.568 | 0.333 | 0.750 | 0.713 |
| 0.637 | 0.567 | 0.746 | 0.583 | 0.613 | 0.404 | 0.361 | 0.083 | 0.890 | 0.797 |
| 0.842 | 0.673 | 0.992 | 0.971 | 0.617 | 0.245 | 0.207 | 0.647 | 0.267 | 0.336 |
| 0.595 | 0.148 | 0.820 | 0.364 | 0.890 | 0.808 | 0.153 | 0.556 | 0.341 | 0.590 |
| 0.771 | 0.727 | 0.006 | 0.305 | 0.760 | 0.553 | 0.553 | 0.360 | 0.182 | 0.510 |
| 0.076 | 0.419 | 0.701 | 0.120 | 0.969 | 0.909 | 0.715 | 0.674 | 0.394 | 0.741 |
| 0.786 | 0.078 | 0.363 | 0.196 | 0.637 | 0.983 | 0.969 | 0.344 | 0.499 | 0.858 |
| 0.804 | 0.926 | 0.106 | 0.150 | 0.087 | 0.090 | 0.091 | 0.209 | 0.534 | 0.908 |
| 0.086 | 0.106 | 0.507 | 0.050 | 0.305 | 0.029 | 0.470 | 0.550 | 0.876 | 0.393 |
| 0.276 | 0.055 | 0.724 | 0.325 | 0.336 | 0.467 | 0.272 | 0.687 | 0.170 | 0.378 |
| 0.743 | 0.288 | 0.413 | 0.223 | 0.355 | 0.439 | 0.760 | 0.528 | 0.168 | 0.510 |
| 0.923 | 0.191 | 0.897 | 0.647 | 0.104 | 0.176 | 0.435 | 0.305 | 0.028 | 0.544 |
| 0.400 | 0.749 | 0.063 | 0.213 | 0.463 | 0.177 | 0.461 | 0.368 | 0.753 | 0.642 |
| 0.244 | 0.916 | 0.120 | 0.394 | 0.780 | 0.897 | 0.520 | 0.831 | 0.564 | 0.256 |
| 0.328 | 0.697 | 0.248 | 0.882 | 0.845 | 0.691 | 0.443 | 0.321 | 0.781 | 0.135 |
| 0.333 | 0.073 | 0.996 | 0.869 | 0.620 | 0.867 | 0.292 | 0.018 | 0.843 | 0.837 |
| 0.515 | 0.798 | 0.594 | 0.993 | 0.770 | 0.002 | 0.673 | 0.896 | 0.012 | 0.345 |
| 0.692 | 0.945 | 0.813 | 0.295 | 0.189 | 0.185 | 0.568 | 0.578 | 0.757 | 0.036 |
| 0.934 | 0.987 | 0.232 | 0.848 | 0.777 | 0.663 | 0.469 | 0.702 | 0.407 | 0.511 |
| 0.741 | 0.346 | 0.398 | 0.883 | 0.282 | 0.678 | 0.740 | 0.222 | 0.015 | 0.696 |
| 0.648 | 0.780 | 0.994 | 0.293 | 0.772 | 0.106 | 0.586 | 0.836 | 0.109 | 0.427 |
| 0.935 | 0.903 | 0.397 | 0.609 | 0.725 | 0.113 | 0.262 | 0.823 | 0.787 | 0.435 |
| 0.911 | 0.599 | 0.572 | 0.894 | 0.647 | 0.410 | 0.024 | 0.069 | 0.984 | 0.442 |
| 0.887 | 0.306 | 0.651 | 0.719 | 0.975 | 0.034 | 0.259 | 0.215 | 0.432 | 0.102 |
| 0.917 | 0.141 | 0.521 | 0.538 | 0.575 | 0.033 | 0.972 | 0.642 | 0.377 | 0.819 |
| 0.410 | 0.813 | 0.810 | 0.509 | 0.908 | 0.014 | 0.915 | 0.669 | 0.193 | 0.296 |
| 0.361 | 0.335 | 0.525 | 0.268 | 0.650 | 0.523 | 0.798 | 0.930 | 0.237 | 0.990 |
| 0.878 | 0.780 | 0.848 | 0.402 | 0.718 | 0.586 | 0.780 | 0.570 | 0.288 | 0.742 |
| 0.456 | 0.905 | 0.827 | 0.613 | 0.020 | 0.748 | 0.478 | 0.771 | 0.261 | 0.735 |
| 0.819 | 0.522 | 0.638 | 0.853 | 0.323 | 0.652 | 0.680 | 0.337 | 0.283 | 0.776 |
| 0.571 | 0.078 | 0.231 | 0.201 | 0.164 | 0.674 | 0.383 | 0.724 | 0.233 | 0.814 |

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|---|---|---|---|---|---|---|---|---|---|
| 0.143 | 0.249 | 0.236 | 0.116 | 0.185 | 0.647 | 0.360 | 0.104 | 0.167 | 0.758 |
| 0.151 | 0.462 | 0.589 | 0.937 | 0.485 | 0.228 | 0.829 | 0.062 | 0.183 | 0.086 |
| 0.903 | 0.396 | 0.037 | 0.408 | 0.953 | 0.224 | 0.533 | 0.203 | 0.030 | 0.660 |
| 0.058 | 0.638 | 0.164 | 0.532 | 0.862 | 0.267 | 0.287 | 0.755 | 0.558 | 0.648 |
| 0.016 | 0.103 | 0.455 | 0.487 | 0.843 | 0.767 | 0.483 | 0.977 | 0.749 | 0.631 |
| 0.007 | 0.476 | 0.789 | 0.647 | 0.313 | 0.189 | 0.666 | 0.242 | 0.029 | 0.016 |
| 0.829 | 0.135 | 0.287 | 0.198 | 0.135 | 0.490 | 0.885 | 0.955 | 0.592 | 0.810 |
| 0.247 | 0.728 | 0.223 | 0.462 | 0.452 | 0.226 | 0.581 | 0.267 | 0.115 | 0.896 |
| 0.944 | 0.024 | 0.407 | 0.994 | 0.730 | 0.418 | 0.987 | 0.915 | 0.143 | 0.178 |
| 0.134 | 0.919 | 0.606 | 0.918 | 0.857 | 0.931 | 0.996 | 0.555 | 0.262 | 0.558 |
| 0.217 | 0.714 | 0.966 | 0.979 | 0.141 | 0.025 | 0.824 | 0.879 | 0.456 | 0.722 |
| 0.772 | 0.060 | 0.433 | 0.439 | 0.041 | 0.909 | 0.169 | 0.627 | 0.550 | 0.356 |
| 0.318 | 0.486 | 0.734 | 0.503 | 0.845 | 0.812 | 0.612 | 0.555 | 0.843 | 0.689 |
| 0.358 | 0.235 | 0.932 | 0.403 | 0.160 | 0.312 | 0.281 | 0.512 | 0.663 | 0.424 |
| 0.780 | 0.450 | 0.751 | 0.831 | 0.388 | 0.602 | 0.978 | 0.272 | 0.205 | 0.226 |
| 0.401 | 0.568 | 0.277 | 0.151 | 0.122 | 0.137 | 0.683 | 0.650 | 0.304 | 0.069 |
| 0.927 | 0.384 | 0.941 | 0.928 | 0.166 | 0.843 | 0.182 | 0.924 | 0.309 | 0.173 |
| 0.463 | 0.623 | 0.519 | 0.801 | 0.256 | 0.846 | 0.141 | 0.773 | 0.689 | 0.913 |
| 0.595 | 0.195 | 0.845 | 0.885 | 0.266 | 0.691 | 0.999 | 0.974 | 0.917 | 0.296 |
| 0.587 | 0.754 | 0.658 | 0.666 | 0.188 | 0.358 | 0.002 | 0.032 | 0.289 | 0.288 |
| 0.047 | 0.791 | 0.129 | 0.018 | 0.298 | 0.154 | 0.396 | 0.028 | 0.178 | 0.743 |
| 0.055 | 0.445 | 0.751 | 0.547 | 0.094 | 0.924 | 0.685 | 0.153 | 0.469 | 0.945 |
| 0.997 | 0.647 | 0.026 | 0.171 | 0.599 | 0.091 | 0.681 | 0.029 | 0.182 | 0.997 |
| 0.646 | 0.164 | 0.474 | 0.680 | 0.969 | 0.932 | 0.394 | 0.922 | 0.188 | 0.579 |
| 0.141 | 0.833 | 0.360 | 0.262 | 0.741 | 0.327 | 0.264 | 0.583 | 0.091 | 0.118 |
| 0.044 | 0.766 | 0.032 | 0.629 | 0.088 | 0.164 | 0.472 | 0.746 | 0.409 | 0.224 |
| 0.102 | 0.799 | 0.323 | 0.588 | 0.725 | 0.685 | 0.698 | 0.471 | 0.746 | 0.545 |
| 0.552 | 0.982 | 0.831 | 0.895 | 0.296 | 0.540 | 0.291 | 0.611 | 0.380 | 0.040 |
| 0.197 | 0.694 | 0.644 | 0.932 | 0.785 | 0.200 | 0.150 | 0.856 | 0.155 | 0.249 |
| 0.766 | 0.010 | 0.814 | 0.528 | 0.297 | 0.881 | 0.091 | 0.181 | 0.436 | 0.520 |
| 0.943 | 0.499 | 0.319 | 0.002 | 0.202 | 0.313 | 0.962 | 0.233 | 0.781 | 0.504 |
| 0.371 | 0.756 | 0.873 | 0.526 | 0.591 | 0.718 | 0.677 | 0.350 | 0.492 | 0.654 |
| 0.680 | 0.749 | 0.553 | 0.233 | 0.029 | 0.308 | 0.452 | 0.643 | 0.020 | 0.078 |
| 0.713 | 0.746 | 0.235 | 0.288 | 0.221 | 0.686 | 0.366 | 0.003 | 0.860 | 0.081 |
| 0.250 | 0.146 | 0.073 | 0.472 | 0.144 | 0.784 | 0.618 | 0.184 | 0.783 | 0.100 |

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|---|---|---|---|---|---|---|---|---|---|
| 0.303 | 0.243 | 0.237 | 0.929 | 0.978 | 0.522 | 0.112 | 0.290 | 0.576 | 0.756 |
| 0.116 | 0.812 | 0.462 | 0.598 | 0.526 | 0.449 | 0.901 | 0.361 | 0.590 | 0.412 |
| 0.903 | 0.601 | 0.389 | 0.704 | 0.230 | 0.211 | 0.192 | 0.175 | 0.861 | 0.168 |
| 0.836 | 0.502 | 0.676 | 0.593 | 0.172 | 0.999 | 0.654 | 0.286 | 0.084 | 0.662 |
| 0.364 | 0.384 | 0.138 | 0.355 | 0.022 | 0.306 | 0.377 | 0.550 | 0.905 | 0.635 |
| 0.300 | 0.517 | 0.405 | 0.093 | 0.551 | 0.380 | 0.489 | 0.277 | 0.355 | 0.932 |
| 0.863 | 0.290 | 0.226 | 0.638 | 0.612 | 0.952 | 0.988 | 0.704 | 0.602 | 0.715 |
| 0.624 | 0.637 | 0.420 | 0.971 | 0.003 | 0.207 | 0.140 | 0.881 | 0.005 | 0.189 |
| 0.687 | 0.399 | 0.074 | 0.828 | 0.091 | 0.640 | 0.740 | 0.405 | 0.406 | 0.255 |
| 0.127 | 0.824 | 0.573 | 0.953 | 0.998 | 0.624 | 0.017 | 0.850 | 0.342 | 0.317 |
| 0.246 | 0.782 | 0.065 | 0.465 | 0.251 | 0.244 | 0.783 | 0.401 | 0.969 | 0.115 |
| 0.283 | 0.996 | 0.606 | 0.823 | 0.650 | 0.383 | 0.089 | 0.103 | 0.618 | 0.042 |
| 0.441 | 0.011 | 0.160 | 0.149 | 0.348 | 0.338 | 0.852 | 0.606 | 0.703 | 0.100 |
| 0.050 | 0.645 | 0.419 | 0.240 | 0.398 | 0.423 | 0.271 | 0.208 | 0.707 | 0.500 |
| 0.068 | 0.581 | 0.741 | 0.633 | 0.928 | 0.360 | 0.920 | 0.756 | 0.935 | 0.127 |
| 0.505 | 0.585 | 0.963 | 0.694 | 0.260 | 0.735 | 0.949 | 0.411 | 0.148 | 0.759 |
| 0.391 | 0.795 | 0.083 | 0.026 | 0.360 | 0.623 | 0.270 | 0.821 | 0.800 | 0.154 |
| 0.161 | 0.600 | 0.401 | 0.634 | 0.564 | 0.793 | 0.825 | 0.743 | 0.934 | 0.049 |
| 0.570 | 0.136 | 0.376 | 0.360 | 0.245 | 0.731 | 0.390 | 0.943 | 0.545 | 0.916 |
| 0.897 | 0.293 | 0.705 | 0.309 | 0.567 | 0.327 | 0.714 | 0.247 | 0.984 | 1.000 |
| 0.066 | 0.649 | 0.685 | 0.327 | 0.340 | 0.410 | 0.595 | 0.199 | 0.376 | 0.988 |
| 0.897 | 0.895 | 0.342 | 0.337 | 0.860 | 0.724 | 0.466 | 0.834 | 0.669 | 0.665 |
| 0.709 | 0.380 | 0.772 | 0.447 | 0.176 | 0.297 | 0.786 | 0.948 | 0.531 | 0.209 |
| 0.499 | 0.332 | 0.202 | 0.545 | 0.977 | 0.839 | 0.663 | 0.827 | 0.332 | 0.606 |
| 0.565 | 0.391 | 0.170 | 0.461 | 0.006 | 0.717 | 0.247 | 0.064 | 0.713 | 0.994 |
| 0.374 | 0.325 | 0.423 | 0.111 | 0.097 | 0.492 | 0.243 | 0.696 | 0.180 | 0.819 |
| 0.269 | 0.387 | 0.430 | 0.222 | 0.246 | 0.974 | 0.890 | 0.823 | 0.553 | 0.582 |
| 0.929 | 0.801 | 0.283 | 0.529 | 0.271 | 0.442 | 0.722 | 0.044 | 0.479 | 0.799 |
| 0.979 | 0.484 | 0.936 | 0.876 | 0.074 | 0.198 | 0.857 | 0.730 | 0.250 | 0.724 |
| 0.345 | 0.404 | 0.792 | 0.440 | 0.050 | 0.103 | 0.146 | 0.350 | 0.435 | 0.500 |
| 0.600 | 0.156 | 0.198 | 0.602 | 0.327 | 0.260 | 0.875 | 0.066 | 0.056 | 0.870 |
| 0.156 | 0.380 | 0.162 | 0.857 | 0.944 | 0.804 | 0.455 | 0.512 | 0.689 | 0.493 |
| 0.445 | 0.881 | 0.033 | 0.696 | 0.368 | 0.809 | 0.286 | 0.442 | 0.751 | 0.367 |
| 0.778 | 0.621 | 0.802 | 0.809 | 0.605 | 0.857 | 0.401 | 0.725 | 0.811 | 0.094 |
| 0.982 | 0.526 | 0.534 | 0.290 | 0.067 | 0.948 | 0.140 | 0.127 | 0.765 | 0.703 |

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|---|---|---|---|---|---|---|---|---|---|
| 0.889 | 0.147 | 0.987 | 0.946 | 0.152 | 0.219 | 0.675 | 0.716 | 0.723 | 0.737 |
| 0.821 | 1.000 | 0.242 | 0.469 | 0.559 | 0.585 | 0.273 | 0.446 | 0.115 | 0.344 |
| 0.067 | 0.814 | 0.878 | 0.123 | 0.527 | 0.039 | 0.405 | 0.875 | 0.428 | 0.391 |
| 0.610 | 0.206 | 0.408 | 0.087 | 0.938 | 0.983 | 0.767 | 0.029 | 0.794 | 0.164 |
| 0.600 | 0.516 | 0.019 | 0.507 | 0.304 | 0.857 | 0.682 | 0.305 | 0.983 | 0.281 |
| 0.983 | 0.821 | 0.785 | 0.048 | 0.530 | 0.556 | 0.701 | 0.174 | 0.794 | 0.035 |
| 0.862 | 0.677 | 0.003 | 0.233 | 0.854 | 0.741 | 0.267 | 0.333 | 0.099 | 0.713 |
| 0.214 | 0.938 | 0.815 | 0.338 | 0.917 | 0.426 | 0.601 | 0.131 | 0.386 | 0.576 |
| 0.169 | 0.305 | 0.428 | 0.138 | 0.263 | 0.149 | 0.129 | 0.500 | 0.282 | 0.269 |
| 0.757 | 0.106 | 0.656 | 0.595 | 0.360 | 0.781 | 0.491 | 0.566 | 0.849 | 0.621 |
| 0.526 | 0.390 | 0.830 | 0.604 | 0.921 | 0.794 | 0.990 | 0.578 | 0.923 | 0.166 |
| 0.291 | 0.783 | 0.925 | 0.491 | 0.779 | 0.561 | 0.958 | 0.002 | 0.274 | 0.411 |
| 0.152 | 0.931 | 0.724 | 0.050 | 0.181 | 0.287 | 0.507 | 0.626 | 0.240 | 0.052 |
| 0.465 | 0.752 | 0.580 | 0.709 | 0.943 | 0.507 | 0.127 | 0.508 | 0.623 | 0.061 |
| 0.218 | 0.370 | 0.425 | 0.093 | 0.997 | 0.845 | 0.270 | 0.635 | 0.482 | 0.020 |
| 0.969 | 0.526 | 0.848 | 0.797 | 0.032 | 0.107 | 0.960 | 0.425 | 0.675 | 0.326 |
| 0.675 | 0.719 | 0.804 | 0.914 | 0.952 | 0.852 | 0.260 | 0.777 | 0.297 | 0.132 |
| 0.104 | 0.260 | 0.590 | 0.682 | 0.223 | 0.454 | 0.792 | 0.402 | 0.043 | 0.189 |
| 0.600 | 0.152 | 0.624 | 0.865 | 0.562 | 0.538 | 0.922 | 0.800 | 0.677 | 0.215 |
| 0.499 | 0.219 | 0.031 | 0.121 | 0.459 | 0.574 | 0.486 | 0.530 | 0.894 | 0.322 |
| 0.956 | 0.352 | 0.629 | 0.836 | 0.299 | 0.572 | 0.523 | 0.597 | 0.369 | 0.231 |
| 0.143 | 0.330 | 0.239 | 0.875 | 0.055 | 0.228 | 0.146 | 0.853 | 0.545 | 0.933 |
| 0.169 | 0.392 | 0.025 | 0.427 | 0.196 | 0.839 | 0.930 | 0.482 | 0.187 | 0.986 |
| 0.366 | 0.834 | 0.279 | 0.883 | 0.299 | 0.735 | 0.760 | 0.040 | 0.573 | 0.033 |
| 0.445 | 0.430 | 0.525 | 0.449 | 0.478 | 0.197 | 0.486 | 0.195 | 0.104 | 0.475 |
| 0.953 | 0.591 | 0.431 | 0.223 | 0.700 | 0.851 | 0.715 | 0.489 | 0.625 | 0.668 |
| 0.211 | 0.997 | 0.601 | 0.785 | 0.101 | 0.473 | 0.124 | 0.182 | 0.547 | 0.620 |
| 0.025 | 0.053 | 0.395 | 0.130 | 0.048 | 0.217 | 0.554 | 0.659 | 0.546 | 0.129 |
| 0.601 | 0.165 | 0.109 | 0.142 | 0.613 | 0.506 | 0.381 | 0.173 | 0.790 | 0.716 |
| 0.855 | 0.443 | 0.874 | 0.866 | 0.932 | 0.427 | 0.913 | 0.900 | 0.016 | 0.685 |
| 0.389 | 0.375 | 0.939 | 0.731 | 0.246 | 0.491 | 0.478 | 0.586 | 0.860 | 0.333 |
| 0.270 | 0.175 | 0.453 | 0.719 | 0.881 | 0.232 | 0.022 | 0.569 | 0.330 | 0.859 |
| 0.278 | 0.198 | 0.841 | 0.402 | 0.647 | 0.432 | 0.097 | 0.795 | 0.862 | 0.975 |
| 0.797 | 0.031 | 0.169 | 0.900 | 0.778 | 0.923 | 0.686 | 0.707 | 0.487 | 0.790 |
| 0.944 | 0.821 | 0.099 | 0.257 | 0.136 | 0.962 | 0.041 | 0.790 | 0.122 | 0.275 |

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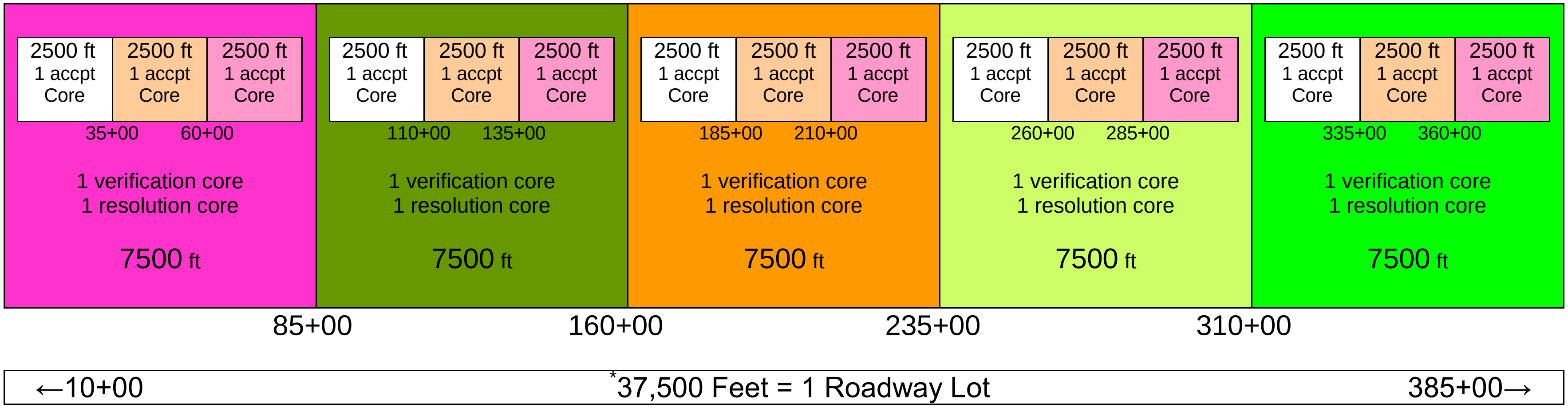
|---|---|---|---|---|---|---|---|---|---|
| 0.215 | 0.152 | 0.693 | 0.642 | 0.706 | 0.418 | 0.156 | 0.064 | 0.241 | 0.704 |
| 0.750 | 0.537 | 0.194 | 0.292 | 0.930 | 0.322 | 0.414 | 0.263 | 0.057 | 0.001 |
| 0.654 | 0.344 | 0.512 | 0.258 | 0.883 | 0.081 | 0.782 | 0.750 | 0.270 | 0.027 |
| 0.531 | 0.014 | 0.110 | 0.081 | 0.205 | 0.788 | 0.483 | 0.646 | 0.186 | 0.659 |
| 0.914 | 0.753 | 0.037 | 0.461 | 0.839 | 0.816 | 0.869 | 0.297 | 0.126 | 0.169 |
| 0.356 | 0.629 | 0.463 | 0.043 | 0.425 | 0.308 | 0.874 | 0.135 | 0.176 | 0.971 |
| 0.154 | 0.434 | 0.026 | 0.710 | 0.497 | 0.452 | 0.642 | 0.407 | 0.109 | 0.523 |
| 0.675 | 0.651 | 0.075 | 0.317 | 0.838 | 0.648 | 0.272 | 0.236 | 0.340 | 0.015 |
| 0.596 | 0.840 | 0.238 | 0.877 | 0.305 | 0.966 | 0.703 | 0.168 | 0.733 | 0.688 |
| 0.764 | 0.545 | 0.185 | 0.784 | 0.538 | 0.817 | 0.261 | 0.855 | 0.484 | 0.300 |
| 0.428 | 0.769 | 0.721 | 1.000 | 0.087 | 0.559 | 0.925 | 0.034 | 0.938 | 0.466 |
| 0.853 | 0.195 | 0.915 | 0.256 | 0.013 | 0.062 | 0.477 | 0.471 | 0.517 | 0.567 |
| 0.528 | 0.790 | 0.645 | 0.423 | 0.762 | 0.130 | 0.155 | 0.321 | 0.697 | 0.661 |
| 0.872 | 0.302 | 0.191 | 0.380 | 0.575 | 0.200 | 0.720 | 0.417 | 0.726 | 0.585 |
| 0.190 | 0.701 | 0.074 | 0.089 | 0.580 | 0.176 | 0.650 | 0.534 | 0.182 | 0.197 |
| 0.199 | 0.762 | 0.730 | 0.272 | 0.574 | 0.584 | 0.190 | 0.809 | 0.123 | 0.739 |
| 0.503 | 0.020 | 0.601 | 0.276 | 0.054 | 0.639 | 0.645 | 0.275 | 0.149 | 0.613 |
| 0.325 | 0.298 | 0.285 | 0.415 | 0.825 | 0.479 | 0.492 | 0.145 | 0.771 | 0.672 |
| 0.531 | 0.067 | 0.236 | 0.545 | 0.219 | 0.747 | 0.965 | 0.044 | 0.680 | 0.436 |
| 0.840 | 0.117 | 0.786 | 0.866 | 0.122 | 0.118 | 0.580 | 0.107 | 0.496 | 0.783 |
| 0.957 | 0.652 | 0.462 | 0.203 | 0.387 | 0.367 | 0.086 | 0.679 | 0.961 | 0.484 |
| 0.656 | 0.888 | 0.538 | 0.282 | 0.270 | 0.236 | 0.280 | 0.608 | 0.886 | 0.845 |
| 0.349 | 0.909 | 0.865 | 0.037 | 0.057 | 0.912 | 0.542 | 0.756 | 0.237 | 0.627 |
| 0.850 | 0.809 | 0.132 | 0.817 | 0.535 | 0.357 | 0.567 | 0.594 | 0.991 | 0.534 |
| 0.702 | 0.299 | 0.240 | 0.624 | 0.127 | 0.325 | 0.100 | 0.689 | 0.605 | 0.031 |
| 0.062 | 0.064 | 0.222 | 0.407 | 0.911 | 0.609 | 0.235 | 0.655 | 0.626 | 0.147 |
| 0.402 | 0.324 | 0.583 | 0.973 | 0.069 | 0.174 | 0.596 | 0.854 | 0.803 | 0.416 |
| 0.832 | 0.420 | 0.835 | 0.476 | 0.116 | 0.355 | 0.125 | 0.963 | 0.682 | 0.288 |
| 0.293 | 0.972 | 0.873 | 0.806 | 0.228 | 0.391 | 0.846 | 0.474 | 0.644 | 0.370 |
| 0.793 | 0.281 | 0.355 | 0.602 | 0.729 | 0.423 | 0.570 | 0.570 | 0.355 | 0.815 |
| 0.976 | 0.434 | 0.056 | 0.245 | 0.890 | 0.682 | 0.532 | 0.585 | 0.267 | 0.241 |
| 0.127 | 0.948 | 0.846 | 0.168 | 0.358 | 0.211 | 0.204 | 0.601 | 0.697 | 0.805 |
| 0.015 | 0.116 | 0.121 | 0.179 | 0.284 | 0.148 | 0.477 | 0.841 | 0.841 | 0.634 |
| 0.177 | 0.393 | 0.876 | 0.529 | 0.266 | 0.447 | 0.799 | 0.365 | 0.392 | 0.851 |
| 0.194 | 0.486 | 0.703 | 0.115 | 0.176 | 0.138 | 0.210 | 0.447 | 0.891 | 0.061 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0.645 | 0.307 | 0.484 | 0.732 | 0.342 | 0.893 | 0.283 | 0.932 | 0.174 | 0.439 |
| 0.496 | 0.774 | 0.083 | 0.773 | 0.200 | 0.867 | 0.224 | 0.996 | 0.902 | 0.756 |
| 0.257 | 0.721 | 0.454 | 0.307 | 0.834 | 0.768 | 0.598 | 0.183 | 0.778 | 0.714 |
| 0.938 | 0.074 | 0.028 | 0.216 | 0.596 | 0.838 | 0.844 | 0.505 | 0.353 | 0.201 |
| 0.322 | 0.961 | 0.555 | 0.181 | 0.753 | 0.173 | 0.548 | 0.889 | 0.844 | 0.393 |
| 0.946 | 0.865 | 0.345 | 0.793 | 0.498 | 0.594 | 0.100 | 0.414 | 0.837 | 0.383 |
| 0.069 | 0.244 | 0.901 | 0.226 | 0.342 | 0.298 | 0.299 | 0.835 | 0.673 | 0.132 |
| 0.400 | 0.486 | 0.578 | 0.680 | 0.443 | 0.827 | 0.519 | 0.837 | 0.429 | 0.324 |
| 0.201 | 0.672 | 0.084 | 0.484 | 0.528 | 0.697 | 0.688 | 0.518 | 0.238 | 0.096 |
| 0.021 | 0.601 | 0.746 | 0.301 | 0.241 | 0.382 | 0.236 | 0.851 | 0.949 | 0.907 |
| 0.530 | 0.917 | 0.236 | 0.599 | 0.759 | 0.404 | 0.994 | 0.465 | 0.372 | 0.047 |
| 0.256 | 0.177 | 0.521 | 0.395 | 0.875 | 0.187 | 0.337 | 0.096 | 0.288 | 0.532 |
| 0.141 | 0.383 | 0.685 | 0.481 | 0.126 | 0.178 | 0.324 | 0.692 | 0.517 | 0.706 |
| 0.308 | 0.018 | 0.773 | 0.039 | 0.582 | 0.634 | 0.834 | 0.468 | 0.445 | 0.631 |
| 0.960 | 0.110 | 0.352 | 0.738 | 0.192 | 0.658 | 0.282 | 0.330 | 0.956 | 0.681 |
| 0.472 | 0.369 | 0.858 | 0.379 | 0.772 | 0.448 | 0.184 | 0.200 | 0.426 | 0.583 |
| 0.149 | 0.221 | 0.544 | 0.913 | 0.416 | 0.705 | 0.061 | 0.964 | 0.931 | 0.742 |
| 0.442 | 0.639 | 0.585 | 0.369 | 0.941 | 0.575 | 0.752 | 0.086 | 0.679 | 0.046 |
| 0.228 | 0.176 | 0.317 | 0.043 | 0.594 | 0.718 | 0.629 | 0.708 | 0.553 | 0.726 |
| 0.724 | 0.766 | 0.251 | 0.290 | 0.233 | 0.118 | 0.129 | 0.156 | 0.205 | 0.245 |
| 0.334 | 0.626 | 0.034 | 0.586 | 0.206 | 0.195 | 0.158 | 0.540 | 0.901 | 0.838 |
| 0.842 | 0.255 | 0.651 | 0.337 | 0.808 | 0.852 | 0.711 | 0.566 | 0.010 | 0.249 |
| 0.518 | 0.141 | 0.307 | 0.233 | 0.098 | 0.335 | 0.354 | 0.942 | 0.239 | 0.661 |
| 0.453 | 0.414 | 0.482 | 0.049 | 0.681 | 0.351 | 0.439 | 0.992 | 0.042 | 0.764 |
| 0.492 | 0.602 | 0.955 | 0.654 | 0.380 | 0.949 | 0.837 | 0.373 | 0.726 | 0.618 |
| 0.075 | 0.840 | 0.024 | 0.866 | 0.166 | 0.256 | 0.123 | 0.310 | 0.294 | 0.474 |
| 0.728 | 0.523 | 0.148 | 0.688 | 0.970 | 0.474 | 0.245 | 0.592 | 0.556 | 0.196 |
| 0.538 | 0.661 | 0.535 | 0.598 | 0.608 | 0.723 | 0.226 | 0.832 | 0.199 | 0.463 |
| 0.314 | 0.102 | 0.392 | 0.030 | 0.671 | 0.352 | 0.200 | 0.389 | 0.913 | 0.702 |
| 0.847 | 0.583 | 0.234 | 0.075 | 0.541 | 0.568 | 0.552 | 0.895 | 0.996 | 0.751 |
| 0.484 | 0.271 | 0.498 | 0.926 | 0.196 | 0.577 | 0.798 | 0.723 | 0.655 | 0.832 |
| 0.598 | 0.264 | 0.305 | 0.779 | 0.933 | 0.152 | 0.714 | 0.079 | 0.213 | 0.467 |
| 0.213 | 0.527 | 0.212 | 0.923 | 0.054 | 0.682 | 0.787 | 0.833 | 0.136 | 0.837 |
| 0.609 | 0.050 | 0.808 | 0.716 | 0.681 | 0.534 | 0.798 | 0.822 | 0.927 | 0.697 |
| 0.791 | 0.831 | 0.645 | 0.196 | 0.685 | 0.937 | 0.078 | 0.316 | 0.067 | 0.561 |




Above is what an ideal lot layout would look like in a continuous 37,500’ roadway lot. Seldom will this perfect situation exist. An example using generated numbers follows.

Sampling for lot layout is in the direction of paving. Transverse layout is from left to right facing the direction of paving.

The 56 numbers generated for this example are:
0.034, 0.802, 0.474, 0.652, 0.211, 0.203, 0.522, 0.649, 0.398, 0.229, 0.605, 0.811, 0.094, 0.690, 0.844, 0.701, 0.413, 0.996, 0.994, 0.810, 0.231, 0.455, 0.606, 0.751, 0.658, 0.360, 0.814, 0.073, 0.138, 0.573, 0.741, 0.705, 0.170, 0.792, 0.534, 0.019, 0.656, 0.425, 0.031, 0.525, 0.874, 0.099, 0.037, 0.185, 0.074, 0.786, 0.240, 0.355, 0.703, 0.555, 0.746, 0.352, 0.251, 0.955, 0.234, 0.645

The first section direction of paving for the lot is from station 10+00 to 233+87. The second section direction of paving for the lot is from station 233+87 to 82+74.

Acceptance cores will be laid out in 2500’ sections with verification and resolution each using 7500’ sublots. There are three (3) 2500’ sections in a sublot with 5 sublots per lot. Mainline Roadway Lots are based on distance and not tonnage in this specification.

| 2500’ | 2500’ | 2500’ | 2500’ | 2500’ | 2500’ | 2500’ | 2500’ | 2387’ |
|---|---|---|---|---|---|---|---|---|
| .034=95+00 | .474=46+85 | .211=65+27.5 | .605=100+12.5 | .094=112+35 | .844=156+10 | .231=165+77.5 | .606=200+15 | .658= |
| .802=9.2’ | .652=7.5’ | .203=2.3’ | .811=9.3’ | .690=7.9’ | .701=8.1’ | .455=5.2 | .751=8.6 | .360= |

35+00 60+00 110+00 135+00 185+00 210+00

Verification core 0.522=49+15 0 .649=7.4’
Resolution core 0.398=39+85 0 .229=2.6’

Ver 0.413=115+97.55 0.996=11.4 0.746=8.6’
Res 0.994=159+55 0.810=9.3’

Ver 0.814=221+12.5 0.073=0.8 0.352=4.0
Res 0.138=170+35 0.573=6.6

85+00 160+00

←10+00 22,387 ft 233+87→

113 ft short of the 22,500 ft. for three (3) complete sublots. Lane width 11.5’

| 2500’ | 2500’ | 2500’ | 2500’ | 2500’ | 2500’ | 113’ |
|---|---|---|---|---|---|---|
| .074=105+89 | .037=131+81.5 | .874=135+89 | .534=169+39 | .170=203+49 | .741=214+21.5 | 226+45 |
| .786=9.8 | .185=2.3 | .099=1.2 | .019=0.2. | .792=9.9 | .705=8.8 | 4.4 |
| | | | .251= 3.1 | | | |

107+74 132+74 182+74 207+74

Ver .240=139+74 .355=4.4
Res .703=105+01.5 .555=6.9

Ver .656=183+54 .425=5.3
Res .031=230+41.5 .525=6.6

157+74 232+74

←82+74 15,113 233+87→

113 ft longer than the 15,000 ft. Lane width 12.5’

Sublot 1:

From station 10+00 – 85+00 = 7500’, 11.5’ lane

Section 1 - 10+00 – 35+00 = 2500’, Random #’s 0.034, 0.802

2500 x 0.034 = 85’ + 10+00 (start of section) = station 95+00
11.5’ x 0.802 = 9.223’ = 9.2’ from left edge

Section 2 - 35+00 – 60+00 = 2500’, Random #’s 0.474, 0.652

2500’ x 0.474 = 1185’ + 35+00 (start of section) = station 46+85
11.5’ x 0.652 = 7.498 = 7.5’ from left edge

Section 3 - 60+00 – 85+00 = 2500’, Random #’s 0.211, 0.203

2500’ x 0.211 = 527.5’ + 60+00 (start of section) = station 65+27.5’
11.5’ x 0.203 = 2.3345 = 2.3’ from left edge

1 Verification core 10+00 – 85+00 = 7500’, Random #’s 0.522, 0.649

7500’ x 0.522 = 3915’ + 10+00 = station 49+15
11.5’ x 0.649 = 7.4635 = 7.4’ from left edge

1 Resolution core 10+00 – 85+00 = 7500’, Random #’s 0.398, 0.229

7500’ x 0.398 = 2985’ + 10+00 = station 39+85
11.5’ x 0.229 = 2.6335 = 2.6’ from left edge

Sublot 2:

From station 85+00 – 160+00 = 7500’, 11.5’ lane

Section 1 - 85+00 – 110+00 = 2500’, Random #’s 0.605, 0.811

2500’ x 0.605 = 1512.5 + 85+00 = station 100+12.5
11.5’ x 0.811 = 9.3265’ = 9.3’ from left edge

Section 2 - 110+00 – 135+00 =2500’, Random #’s 0.094, 0.690

2500’ x 0.094 = 235’ + 110+00 = station 112+35
11.5’ x 0.690 = 7.935’ = 7.9’ from left edge

Section 3 - 135+00 – 160+00 = 2500’, Random #’s 0.844, 0.701

2500’ x 0.844 = 2110’ + 135+00 = station 156+10
11.5’ x 0.701 = 8.0615 = 8.1’ from left edge

1 Verification core 85+00 – 160+00 = 7500’, Random #’s 0.413, 0.996, 0.746

7500’ x 0.413 = 3097.5’ + 85+00 = station 115+97.5’

11.5' x 0.996 = 11.454' **<1' from an unsupported edge. Choose another random number from the list and recalculate. Use the 51st number in the list.**
11.5' x 0.746 = 8.579' = 8.6' from left edge

1 Resolution core 85+00 – 160+00 = 7500', Random #'s 0.994, 0.810

7500' x 0.994 = 7455' + 85+00 = station 159+55
11.5' x 0.810 = 9.315' = 9.3' from left edge

Sublot 3:
From station 160+00–233+87 = 7387', 11.5' lane and 233+87–232+74 = 113', 12.5 lane
7387' + 113' = 7500'

Section 1 – 160+00 185+00 = 2500', Random #'s 0.231, 0.455

2500' x 0.231 = 577.5' + 160+00 = station 165+77.5'
11.5' x 0.455 = 5.2325' = 5.2' from left edge

Section 2 - 185+00 – 210+00 = 2500', Random #'s 0.606, 0.751

2500' x 0.606 = 1515' + 185+00 = station 200+15
11.5 x 0.751 = 8.6365' = 8.6' from left edge

Section 3 - 210+00 – 233+87 and 233+87 – 232+74, Random #'s 0.658, 0.360
2387' + 113' = 2500'

2500' x 0.658 = 1645' + 210+00 = station 226+45
11.5' x 0.360 = 4.14' = 4.4'
This section has two lane widths. 11.5' is used because the longitudinal random number places the core in the section that is 11.5' wide.

1 Verification core 160+00 – 233+87 and 233+87 – 232+74, = 7500'
Random #'s 0.814, 0.073, 0.352

7500' x 0.814 = 6112.5 + 160+00 = 221+12.5
11.5 x 0.073 = 0.8395' from left edge. Because this edge is unsupported the next random number will be used to recalculate.
11.5 x .352 = 4.048 = 4.0' from left edge

1 Resolution core 160+00 – 233+87 and 233+87 – 232+74, = 7500'
Random #'s 0.138, 0.573

7500' x 0.138 = 1035' + 160+00 = station 170+35
11.5' x 0.573 = 6.5895' = 6.6' from left edge

Sublot 4:
From station 232+74 – 157+74 = 7500', 12.5' lane

Section 1 – 232+74 – 207+74 = 2500’, Random #’s 0.741, 0.705

Because the stations run from high to low, you subtract to find the core location.

2500’ x 0.741 = 1852.5’. 232+74 – 1852.5’ = station 214+21.5
12.5’ x 0.705 = 8.8125’ from the left edge looking in the direction of paving

Section 2 – 207+74 – 182+74 = 2500’, Random #’s 0.170, 0.792

2500’ x 0.170 = 425’. 207+74 – 425’ = station 203+49
12.5 x 0.792 = 9.9’ from left edge

Section 3 - 182+74– 157+74 = 2500’, Random #’s 0.534, 0.019, 0.251

2500’ x 0.534 = 1335’. 182+74 – 1335’ = station 169+39
12.5’ x 0.019 = 0.2375’. Because this edge is unsupported the next random number will be used to recalculate.
12.5’ x 0.251 = 3.1375’ = 3.1’ from the left edge

1 Verification core 232+74 – 157+74 = 7500’, Random #’s 0.656, 0.425

7500’ x 0.656 = 4920’. 232+74 – 4920 = station 183+54
12.5 x 0.425 = 5.3125’ = 5.3’ from the left edge

1 Resolution core 232+74 – 157+74 = 7500’, Random #’s 0.031, 0.525

7500’ x 0.031 = 232.5’. 232+74 – 232.5 = station 230+41.5
12.5 x 0.525 = 6.5625’ = 6.6’ from the left edge

Sublot 5:

From station 157+74 – 82+74 = 7500’, 12.5 lane

Section 1 – 157+74 – 132+74 = 2500’, Random #’s 0.874, 0.099

2500’ x 0.874 = 2185’. 157+74 – 2185’ = station 135+89
12.5’ x 0.099 = 1.2375’ = 1.2’ from left edge

Section 2 – 132+74 – 107+74 = 2500’, Random #’s 0.037, 0.185

2500’ x 0.037 = 92.5’. 132+74 – 92.5’ = station 131+81.5
12.5’ x 0.185 = 2.3125’ = 2.3’ from left edge

Section 3 – 107+74 – 82+74 = 2500’, Random #’s 0.074, 0.786

2500’ x 0.074 = 185’. 107+74 – 185’ = station 105+89
12.5’ 0.786 = 9.825’ = 9.8’ from left edge

1 Verification core 157+74 – 82+74 = 7500’, Random #’s 0.240, 0.355

7500’ x 0.240 = 1800’. 157+74 – 1800’ = station 139+74

12.5’ x 0.355 = 4.<u>4</u>375’ = 4.4’ from the left edge

1 Resolution core 157+74 – 82+74 = 7500’, Random #’s 0.703, 0.555

7500’ x 0.703 = 5272.5’. 157+74 – 5272.5 = station 105+01.5
12.5 x 0.555 = 6.<u>9</u>375’ = 6.9’ from the left edge

# PART 3 – APPENDIX

**Levels and requirements for Asphalt Plant Qualified Tester and Certification**

**Qualified Aggregate Tester**

Introduction to Standard Specifications
Math for Construction Personnel
Sampling of Aggregate and Aggregate Mixtures
Sampling of Asphalt Materials
Determination of Moisture Content of Aggregates
Sieve Analysis of Fine and Coarse Aggregates
Amount of Material Finer than #200 Sieve in Aggregate by Wash
Splitting and Quartering Samples
Standard Method of Test for Bulk Density (Unit Weight) and Voids in Aggregate
Aggregate Specialty Area Examination

Technician must begin HMA Level 1 Qualified Technician Training within 1 year of Proficiency Sample Program Participation.

**Qualified Asphalt Concrete Plant Level I**

Must participate in Proficiency Sample Program
No experience required
Must have completed Qualified Aggregate Tester
Basic Asphalt Concrete Plant Inspection
Lecture:

- Superpave Materials
- Asphalt Mixture Volumetrics
- Gyratory Compaction
- Quality Control and Acceptance
- Basic Asphalt Mixture Plant Operations

Performance:

- Specific Gravity and Density of Compressed Asphalt Mixtures
- Mechanical Analysis of Extracted Aggregate
- Determination of the Moisture Content of Asphalt Concrete
- Determination of the Asphalt Content of Asphalt Mixtures by the Ignition Method
- Theoretical Maximum Specific Gravity of Asphalt Concrete Mixtures
- Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the Superpave Gyratory Compactor

HMA Level I Specialty Area Examination

**Certified Asphalt Concrete Plant Level II**

6 months experience required
Must participate in Proficiency Sample Program
Required for QC Plant Technicians and LADOTD District Asphalt Specialists
May review and verify Job Mix Formula (JMFs) and perform asphalt tests for record.
Math for Construction Personnel vol 2
Lecture:

- HMA Superpave Aggregate Properties
- Water Susceptibility of HMA Mixtures
- Review of JMF Submittals

Performance:

- Sand Equivalent of Soils and Fine Aggregate

Fine Aggregate Angularity
Coarse Aggregate Angularity
Specific Gravity and Absorption of Fine Aggregates
Specific Gravity and Absorption of Coarse Aggregates
Flat and Elongated Particles
Test for Hamburg Wheel –Track Testing of Compacted HMA
Loose Mix and Compressed Mix Testing and Analysis

HMA Level II Specialty Area Examination

**Certified Asphalt Concrete Plant Level III**

Authorized to submit JMF proposals for record
QC Mix Designer requirement and Asphalt Specialist Technician DCL requirement
12 months experience in asphalt QC or QA
Lecture:
Mix Design Steps and Approval
Performance:
Batching Aggregates and Asphalt Binder for Producing Trial Blends
HMA Level III Specialty Area Examination

Louisiana Department of Transportation and Development

DOTD 03-22-3094
Adopted 08/14

# SUPERPAVE ASPHALTIC CONCRETE ROADWAY REPORT

| **Proj. # H.** | | **Lot #** | | **Sublot** | | ***Primary* Mix Use** | | **JMF** | | **Design Level** | | **Mix Type** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| **Submitter Code** | | **Pavement Code** | | **Spec Code** | | **Plant H** | | **Nom. Max Aggr. Size** | | **Adj. Factor** | |
|---|---|---|---|---|---|---|---|---|---|---|---|

| **Project Engineer** | | **Start Date** | | **End Date** | | **Gmm** | | **Res Gmm** | |
|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| From Station | | + | | To Station | | + | | Location | |
| From Station | | + | | To Station | | + | | Location | |
| From Station | | + | | To Station | | + | | Location | |
| From Station | | + | | To Station | | + | | Location | |

| Tons in Lot | | |
|---|---|---|
| Previous | This Sublot (**U**) | **Total** |
| | | |
| *****Yield***** | | |
| Sq Yards (**W**) | Theo. Yield | **Yield** |
| | | |
| 110 lb/yd$^2$/in x Plan Thick ÷ Adj. factor= Theo | | U x 2000÷W |

| *****Roadway Cores***** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Core** | **I.D.** | **Mix Use** | **Date** | **Station** | **Thickness** | **Mass in Air (A) (Wt.)** | **Mass in $H_2O$ (B) (Wt.)** | **Mass SSD (C) (Wt.)** | **Bulk Sp Gr (P) A/(C-B)** | **% Density (P/Gmm x 100)** |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

A Lot is 37,500'. A sublot is 7500'. A section of a sublot is 2500'.

| **Random #s** | Acceptance | Acceptance | Acceptance | Verification | Resolution |
|---|---|---|---|---|---|
| Longitudinal | | | | | |
| Transverse | | | | | |

| | |
|---|---|
| **Pay Item:** | |
| **Comments:** | |
| | |
| | |
| | |
| | |

**Chain of Custody: I attest to the secure transport & safe handling of the listed roadway core samples and that they are indeed the cores sampled by the certified inspector & have not been tampered with while in my custody.**

**1st** ____________________

**2nd** ____________________

**3rd** ____________________

**Certified Roadway Inspector for DOTD:** ____________________ **Date:** __________

Density, %$G_{mm}$ Required__________

**Contractor Represenative:** ____________________ **Date:** __________

% Roadway Density Pay__________

**Approved** ____________________ **Date:** __________

# Superpave Asphaltic Concrete Codes

## Design Level Codes

| Design Level | Code |
|---|---|
| 1 | 1 |
| 1F | 1F |
| 2 | 2 |
| 2F | 2F |
| SMA | SMA |
| Thin Lift | TL |
| A | A |

## Mix Type Codes

| Code | Description |
|---|---|
| 1 | Incidental Paving |
| 2 | Wearing Course |
| 3 | Binder Course |
| 4 | Base Course |

## Mix Use Codes

| Code | Description |
|---|---|
| 01 | WC Roadway |
| 02 | Patching Roadway |
| 03 | Leveling |
| 04 | Widening |
| 05 | WC Shoulder |
| 06 | Turnouts Roadway *(Full Thickness)* |
| 07 | Airport (*Surface Tol. Required)* |
| 08 | Misc. *(Including Driveways)* |
| 09 | Binder Roadway |
| 10 | Base Roadway |
| 11 | Binder Shoulder |
| 12 | Base Shoulder |
| 13 | Patching Shoulder |
| 14 | Joint Repair |
| 15 | Airport *(No Surface Tol.)* |

## Pavement Codes

| Code | Description |
|---|---|
| 01 | All Interstates, multi-lift new construction and overlays more than two lifts |
| 02 | One or two lift overlays over cold planed surfaces and two lift overlays over existing surface |
| 03 | Single lift overlays over existing surfaces |
| 04 | Binder courses |
| 05 | Turnouts, crossovers, detour roads, parking areas, and roadway or shoulder sections less than 500 feet (150 mm) in length |
| 06 | Secondary areas |